THE QUARTERLY

JOURNAL OF SCIENCE

CONDUCTED BY

SIR W. FAIRBAIRN, BART., F.R.S.; WILLIAM CROOKES, F.R.S.; ROBERT HUNT, F.R.S.; H. WOODWARD, F.G.S., F.Z.S.;

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EDITOR.

VOLUME VII.

With Illustrations on Copper, Stone, and Wood.

LONDON:

LONGMANS, GREEN, AND CO., PATERNOSTER ROW.

Paris: FRIEDRICH KLINCKSIECK. | Leipzig: ALFONS DÜRR.

MDCCCLXX.

LONDON: PRINTED BY W. CLOWES AND SONS, STAMFORD STREET AND CHARING CROSS.

CONTENTS OF No. XXV.

NOTICES OF SCIENTIFIC WORKS.

CONTENTS.

CHRONICLES OF SCIENCE,

With Proceedings of Learned Societies, and Recent Scientific Literature.

CONTENTS OF No. XXVI.

NOTICES OF SCIENTIFIC WORKS.

CHRONICLES OF SCIENCE,

With Proceedings of Learned Societies, and Recent Scientific Literature.

CONTENTS OF No. XXVII.

NOTICES OF SCIENTIFIC WORKS.

CHRONICLES OF SCIENCE,

With Proceedings of Learned Societies at Home and Abroad, and Notices of Recent Scientific Literature.

CONTENTS OF No. XXVIII.

NOTICES OF SCIENTIFIC WORKS.

CHRONICLES OF SCIENCE,

With Proceedings of Learned Societies at Home and Abroad, and Notices of Recent Scientific Literature.

EDITORIAL ANNOUNCEMENT.

THIS number of the *Quarterly Journal of Science* brings to a close a series which has for seven years been conducted under one management, and as the periodical now passes out of the hands of its present Editor, he craves permission to say a few words concerning his stewardship.

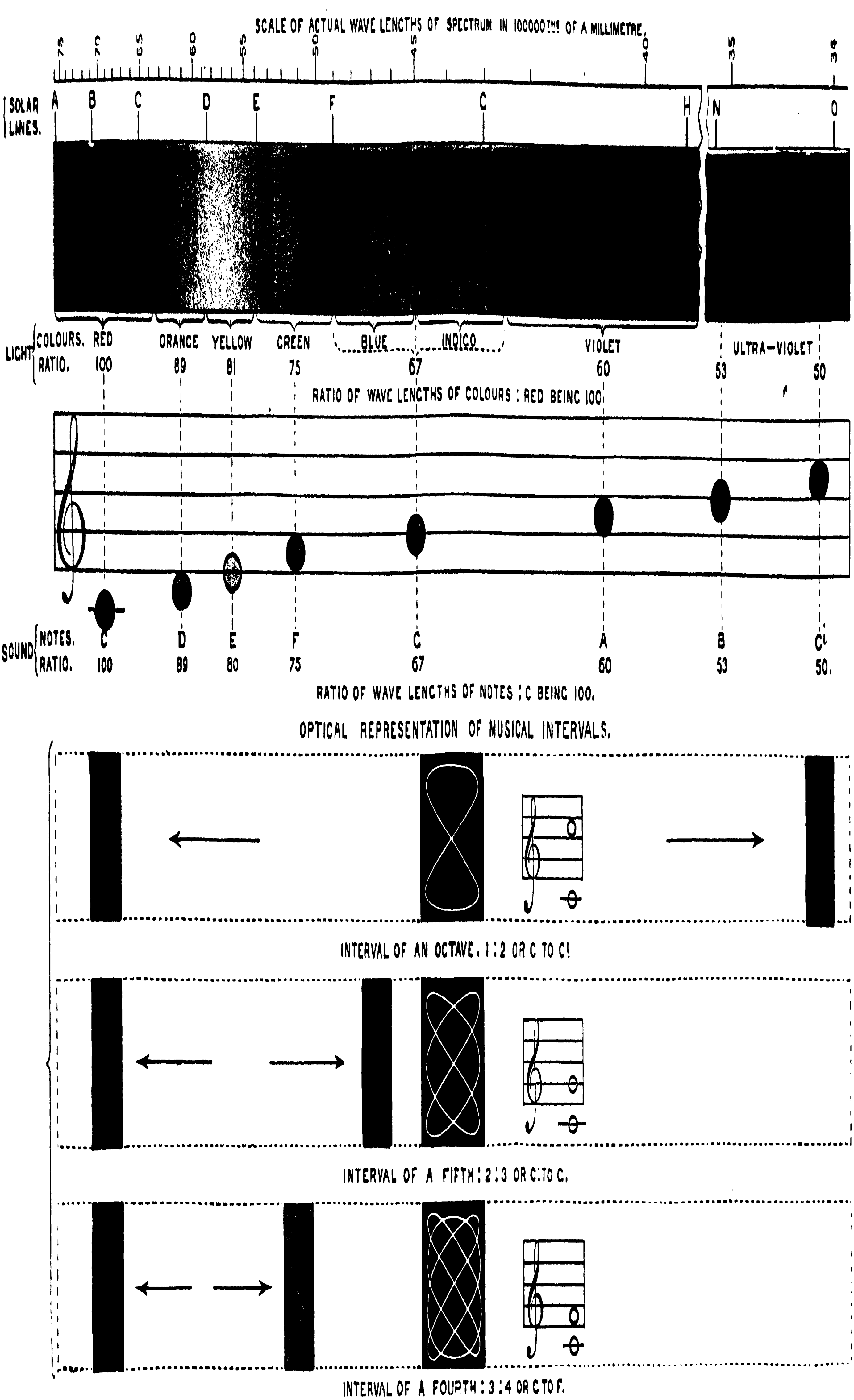
Of the status which the Journal has acquired, it will be the most becoming to say but little. The list of publications regularly acknowledged in each number as having been received from authors and learned societies in all quarters of the civilized world, sufficiently indicates that it has found readers in every clime and nationality, whilst the best criterion of its scientific value is its list of contributors.

Amongst those who have from time to time communicated to its pages the fruits of their labours or the result of their reflections are the well-known names of ANSTED, CARPENTER, CROOKES, DAUBENY, FAIRBAIRN, FRANKLAND, GEIKIE, GLADSTONE, HERSCHEL the Elder, HUGGINS, HULL, HUNT, LACAZE DUTHIERS, The LANKESTERS (father and son), MALLET, CHALMERS MORTON, NASMYTH, ODLING, PENGELLY, PHILLIPS, RAMSAY, ROLLESTON, SCOTT RUSSELL, SCLATER, ANGUS SMITH, SORBY, BALFOUR STEWART, WILLIAM TURNER, ALFRED WALLACE, and others hardly second to those in reputation. Some of the foregoing, along with other earnest, sound, scientific writers, have from quarter to quarter chronicled the progress of scientific discovery, each in his particular branch, and only once or twice during seven years does the Editor recollect having received a remonstrance for unfair criticism. But the experience acquired during the past history of the Journal clearly points to the necessity for a change in its management. The names of CHURCHILL and LONGMAN are sufficient guarantees that all has been done that was possible to make the Journal a permanent contribution to our scientific literature. One defect, however, has been the absence of its Editor from the centre of English intelligence, and that will be henceforward removed.

In the interests of science only, the present Proprietors and Editor have transferred the property and management of the Journal to a gentleman whose name has been conspicuous on its title-page from its commencement.

MR. WILLIAM CROOKES, F.R.S., *Editor of the 'Chemical News,' of 3, Horse-shoe Court, Ludgate Hill,* will henceforward be the sole Proprietor and Editor of the 'QUARTERLY JOURNAL OF SCIENCE.' He is a valued friend of the present Editor, who will continue to give him his cordial and earnest support, and who now solicits for his successor the same kind consideration as he has himself received from his collaborateurs and from the readers of the Journal.

THE EDITOR.



CORRELATION OF COLOUR AND MUSIC.

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THE QUARTERLY

JOURNAL OF SCIENCE

JANUARY, 1870.

I. LIGHT AND SOUND:

AN EXAMINATION OF THEIR REPUTED ANALOGY.

By W. F. Barrett, F.C.S., Natural Science Master at the London International College, &c.

Long before we knew anything of the origin either of sound or light, the existence of an analogy between these forces had been the subject of speculation by some philosophers. But the idea of such an analogy did not originate in philosophy; it was not confined to a few; it resulted in more than speculation. From the earliest times we find among all nations a crude perception of a similarity between sound and colour. This perception became rooted in their languages. The same words, in many cases, were employed to denote either light, or sound. A vivid impression received by the eye was equivalent to a forcible shock received by the ear: thus, the English "loud," the French "criard," the German "schreiend," are identical expressions, relating to sound, also applied to glaring colours. Faintness of vision and feebleness of voice were spoken of as one. Our own words *dim* and *dumb* were probably cognate terms in Anglo-Saxon.

It is easy to trace this correspondence in language much farther, but that is not our present business. Let us inquire if this wide-spread mental analogy between sound and colour rests upon a physical basis. Is it true that light and sound are alike, and if so in what way are they alike? How can the swift flash from a gun be said to resemble the sluggish report that follows? Except æsthetically, where is the likeness between a painting by Raphael and a theme by Beethoven?

At the outset let us remark that no attempt will be made to show the identity of light and sound: it is their resemblance, their *parallelism*, and not, of course, their oneness we wish to establish. A parallelism that probably is metaphysical as well as physical; so that the estimation of beauty of colouring and harmony of sound may, hereafter, be found to resolve themselves into mental actions

essentially the same. Here, however, we have solely to deal with the physical aspect of the question. In pursuit of our object it will be necessary to compare the principal phenomena of light and sound, and for this purpose it will be convenient to break up the subject into sections. If the analogy be just, it will assuredly gather strength as the comparison proceeds; if it be false, then each section cannot fail to force this fact upon the mind. In either case the result ought to be profitable, if we simply seek the truth.

§ 1. Origin of Light and Sound.

Light and sound are both the products of vibratory motion. But to evolve light the motion must be enormously swift, whilst to produce sound the motion must be comparatively slow. In the former case only impalpable molecules can be made to attain the requisite swiftness—light is therefore a *molecular motion* of vibration. In the latter case visible masses of matter can be moved to and fro with the necessary speed: sound is therefore usually the product of a *molar motion* of vibration. Further, to continue the light, or to sustain the sound, the to-and-fro motion must be performed in equal times; it must be *isochronous.* If not isochronous the light will be either intermittent or varying in colour, and the sound will be either a noise or musical notes of varying pitch.

Now comes a remarkable point. Sound and even music are usually produced by a disturbance very different from a vibratory motion. If we hit a tuning-fork on our knee, strike the strings of a piano, or pluck the strings of a harp, we produce music by rough mechanical means; so the noise of hammering, the roar of cataracts, the whistling of the wind, or "the scream of a maddened beach," are all sounds, that is motions of vibration, produced by a rude motion of translation. Light, also, can be evolved by similar agency. The rubbing of two pieces of quartz or sugar, the sparks from a flint or steel, and the incandescence produced by the friction of meteors against the air are familiar examples of light generated by mechanical means.

How can we account for the transition from molar to molecular motion, from an impulse, such as a blow, to a regular pendulum-like swing? A well-established law of mechanics is no doubt the true explanation. This law may be stated as follows:*—"That if a body receive a shock and sufficient time be allowed to elapse so that the initial disturbance is destroyed by friction, imperfect elasticity and other causes, the final resultant motion will be vibratory and isochro-

* This appears to be a *fundamental law of the universe;* namely, that an original impulse of any kind finally resolves itself into periodic or rythmic motion. Does not this throw light upon the periodic motion of planets as well as the vibratory motion of atoms? Possibly, in some such way, we may hereafter learn to understand the musical *rôle* of nature.

nous." Here, then, we have at once the explanation, and the analogy of the mechanical origin of luminous and sonorous vibrations.

It is possible, however, to produce sound as well as light by a *molecular* motion of vibration. This is the case when a wire or rod is rubbed longitudinally; and, as might be predicted, the sound thus obtained is far more shrill than when the same body vibrates transversely. Here, indeed, in longitudinal vibration, there are some striking points of contact between light and sound. For if a beam of polarized light be transmitted through a strip of glass, as soon as the glass, by rubbing it longitudinally, is caused to emit a sound, the light is powerfully affected.

Light and sound have, further, a common origin in molecular change when they are generated by chemical action; thus light and more or less of sound attends combustion; and, directly or indirectly, sound and more or less of light attend the explosion of fulminating powders. Again, light is produced by electricity, as in lightning or the electric spark and electric light, and sound simultaneously accompanies each of these phenomena. Light attends the quick evolution of heat, and sudden heat is productive of the loudest sounds, as in the explosion of mixed oxygen and hydrogen gases.

Now, as light and sound are both the products of *motion*, the law of the conservation of force teaches us that neither one nor the other can have been produced without the loss of an equivalent amount of motion, that is force, elsewhere; and, moreover, that neither can have disappeared without the production of an equivalent motion or force of another kind. This being so, the doctrine of the correlation, or mutual convertibility, of the physical forces comes in and shows us the possibility, not at once perhaps but through intermediate steps, of exchanging light for sound and sound for light. As it is, already we know that the quenching of both light and sound, by absorbing media, results in the production of the same mode of motion, namely, that which we designate *heat*.

§ 2. The Propagation of Light and Sound.

Originating in vibratory motion, let us now inquire in what manner the forces of light and sound reach the eye and ear respectively. When a stick is allowed to swing to and fro in still water, the motion is communicated to the medium around, and a series of waves travel outward from the centre of disturbance. The motion, or *vis viva*, of the stick, though retarded and finally brought to rest by the friction of the water, is not lost. The movement has been delivered to the water, and part of it has reappeared in the form of the waves we noticed. The same considerations apply to light and sound. When a bell is struck its vibrations are delivered to the air around; a system of aerial pulses or waves is thus generated,

which reaching the ear give rise to the sensation of sound. When a substance is made incandescent, the luminous vibrations do not throw the air into undulation; a finer and more elastic medium is requisite to accept and carry on molecular motion. We have abundant reason to believe that such a medium exists; we term it the *luminiferous ether.* To this ether, then, the luminous body communicates its motion. Here, also, a system of waves is produced which, striking the eye, finally give birth to the sensation of light. There is, however, this difference between the sound-waves of the air and the light-waves of the ether, that whereas the former move to and fro longitudinally, the latter vibrate transversely. A cornfield ruffled with gusts of wind exhibits waves like those of sound; the water of a lake thrown into ripples by a disturbance exhibits waves like those of light. The upper figure, L, in the accompany drawing (Fig. 1) shows a single plane-wave of light: the

FIG. 1.

lower, S, a single wave of sound. Each has at N its node, or place of rest, and at V its vibrating segment, or place of greatest motion. The sizes of the two waves are vastly disproportionate. The average length of a sonorous wave, say that of the middle C in the piano, is about 50 inches from N to N′. The average length of a luminous wave, say that of green light, is only the $\frac{20}{1000000}$th part of an inch from N to N′. This great difference must not stagger us in tracing out our analogy. The element of size does not enter into the region of law. The truth of this statement will become evident as we see laws obeyed in like manner by light and sound; by undulations, one set of which are millions of times the size of the other.

Another strong point in this analogy is presented by the phenomena of *Interference.* From an inspection of Fig. 1, it will readily be seen how this is produced. Let L be a series of waves; suppose a second series, of exactly the same length as L, to start just half an undulation later; it will be clear that the crest of one set will coincide with the hollow of the other. They will thus mutually destroy each other, and darkness will be the product of

two luminous undulations thus related. In the same way one sound-pulse may obliterate another, and two sounds thus result in silence. If, for example, a vibrating tuning-fork, placed near the ear, be slowly turned on its axis, four times in each revolution, a position will be reached where no sound is heard. This occurs when the prongs are oblique in reference to the ear, and the waves generated by each prong exactly interfere. If the interference be only partial, *beats*, or intervals of sound and silence, will be produced.

Returning now to the sounding-bell: its motion chiefly spends itself on the air. Hence, when we remove the air from around a sounding body, the vibration continues far longer than otherwise it would. In such a case no sound is heard: internal friction finally brings the sonorous body to rest as a whole, and molecular motion or heat is the result. But in removing the air we do not, and we cannot in any way as yet known, remove the luminiferous ether; by which ether heat is propagated as well as light. Hence the heat-motion resulting from what originally was a sounding body at last escapes from the enclosure in the form of ethereal undulations.

Now when heat spreads by the ether in this way, we denominate it *radiant heat;* and, as we might expect, all the laws common to light are also common to radiant heat, for both are undulatory motions of the selfsame ether.* But whilst the propagation of light only takes place (so far as we yet know) by means of this ether, heat, on the contrary, spreads itself in two ways. It may be propagated from particle to particle by tangible matter, and the phenomenon is then termed conduction; or in waves by the ether, and the phenomenon is then, as we have seen, termed radiant heat. Now sound, like heat, may also be propagated by gross matter, and this likewise is called conduction; it may further, as already mentioned, spread itself in waves by the air, and in this form we may conveniently call it *radiant sound.* Light being only known in the radiant form, obviously it will only be in the phenomena of radiant sound that we shall be justified in further seeking the analogy to light. This we shall do in a succeeding section.

Here, however, it is important to note that we might expect an analogy between the phenomena of sound-conduction and heat-conduction. This is the case: taken in connection with the foot-note below, considerable support is thus given to the analogy of sound and light. Broadly viewed, the best conductors of sound are the best conductors of heat, and *vice versâ.* Conduction in both cases is best through solids and worst through gases. Metals are the best conductors of sound and also of heat. In one very

* The selective absorption of radiant heat by various media (thermocrosis), the phenomena of calorescence—or the conversion of radiant heat into light—and the warming of a black surface by purely luminous rays, demonstrate the fact that radiant heat is only another phase of light.

curious and well-established instance (though probably by no means the only one), the analogy runs very close. It has been observed that in wood *sound* is conducted with different facility in three directions. Lengthways, or along the grain, the conduction is best; across the rings or grain it is much worse; and tangential to the rings it is worst of all. Exactly the same facts, and in the same order, have been found to hold good as regards the conduction of *heat* in wood. But what is true of the conduction of heat is in every case, even in this last, equally true of the conduction of another force, namely, electricity. Now the conduction of electricity strongly resembles the conduction of sound; inasmuch that while the rate of propagation of *sound* through liquids is increased by increase of temperature, it is decreased in solids by the same cause. So likewise it is found that the same causes produce the same effects on similar substances in the rate of propagation of *electricity*. Thus, in the first place, we link light on to heat, and then heat on to sound; after that, heat on to electricity, and here, at last, electricity on to sound, whilst the connection between sound and light it is our object to set forth in this article. How this incidental fact opens up for a moment the oneness of the diverse forces which play around the world! We are encircled with wonder and with mystery, but every now and then facts such as these arise, which lead us to believe that perfect unity and simplicity lie somewhere in the back-ground.

§ 3. The Perception of Light and Sound.

At first it would appear hopeless to seek for any analogy between organs so essentially different as the eye and ear. It must, however, be borne in mind that the functions of those organs are not only to receive the impressions of light and sound, but also to gather up and suitably present the wave-motion which impinges upon them. Owing to the vast difference in tenuity and elasticity of the media which convey light and sound, we should expect to find the very difference we observe in the apparatus contrived for hearing and seeing. Nevertheless it is possible to trace some correspondence of parts in the eye and the ear; and there have not been wanting physiologists who have pushed this view to a detailed and fanciful extreme. The reader who wishes for further information on this presumed resemblance of the two organs will find it given in a recent work by Dr. Macdonald,* to which we may have occasion again to refer.

But there is a remarkable analogy, very much overlooked, which appears to hold good between the perception of the respective impressions of light and sound. When we consider the multitude and complexity of the sounds we hear in a concert, and when we remember the extent, the diversity of colour and appear-

* 'Sound and Colour,' by Dr. Macdonald, F.R.S. Longmans, 1869.

ance of a landscape, it would appear almost inconceivable how such varied impressions could be individually conveyed to the mind. This intricate problem is solved in the most exquisite manner; moreover, in a manner that appears to be essentially the same in the case of the eye and the ear.

Let us approach this analogy with an illustration. When a piano is opened an attentive listener will readily discover that every time a note is sung in the room, that string of the piano which would have yielded the same note is thrown into *sympathetic vibration.* If the note be changed, another and corresponding string responds. Imagine now that a deaf man has his fingers lightly touching the strings of the piano; he will perceive when they vibrate and which vibrates. He will thus become conscious what note has been sung. A similar arrangement to the foregoing is fitted within each of our ears. In the inner ear there is a contrivance known as Corti's organ, which consists of no less than 3000 differently strained fibres. These fibres constitute the outward extremity of the auditory nerve: a vibration of any one of them immediately travels to the brain. According to one of the greatest living investigators, Helmholtz, it is believed that one or more of the fibres enters into sympathetic vibration whenever a sound reaches the ear. Corti's organ is to us, therefore, merely a refinement and extension of what the piano was to the deaf man. M. Hensen's experiments upon the means of hearing in the crustacea confirm this view.

As, however, it would be impossible for the strings of a piano to vibrate if the note were beyond the range of the instrument in either direction, so also there is a limit to the perception of sound by the ear. If the aerial waves recur more quickly than 38,000 times a second, no sound at all is heard, however intense the vibration. If the waves recur slower than sixteen times a second, they are inaudible as a continuous sound. Hence the *extreme* range of our hearing embraces about eleven octaves. This limit varies slightly in different persons, as first shown by Dr. Wollaston.* For example, some persons whose hearing is otherwise good cannot hear the chirp of a cricket or the squeak of a bat. Moreover, one ear is often more sensitive than the other,† and some ears are more sensitive to one class of sounds than to others.

Now, with regard to vision, a similar arrangement to that in the ear appears to exist at the back of the eye. The optic nerve there

* 'Phil. Trans.,' 1820, p. 306.

† When travelling in Norway last year the writer observed that on one occasion the sounds from myriads of grasshoppers were heard, but on closing the left ear there was perfect silence: opening the left ear and closing the right ear, the sound was heard as loud as ever. The difference, where it exists, may readily be noticed by listening to the ticking of a watch. The cause, probably, arises from habitually sleeping on the right side.

spreads out to form the retina, upon the terminal filaments of which are scattered minute bodies, the so-called "rods and cones." Upon these bodies the luminous waves impinge, and it is considered probable that each accepts only that vibration which synchronizes with its own: in other words, that the perception of light arises from sympathetic vibration.* If this be the case, we should expect that the range of vision would, like hearing, fall within certain limits of pitch. This is well known to be the fact. Albeit the limit of vision is much more restricted than the limit of hearing; for with the utmost care we are unable to perceive vibrations of the ether beyond the range of an octave; that is, from the solar line A to L of the spectrum (see Plate). This extent needs, indeed, a practised eye; ordinarily the range corresponds to the interval termed a sixth in music, that is from the red to the violet extremity of the spectrum. The lower limit of vision, the extreme red, is produced by ethereal waves recurring 458 millions of millions of times each second; if the undulations be slower than this, they are invisible. The higher limit of vision, the extreme violet, is produced by luminiferous waves recurring 727 millions of millions of times each second; if faster, they do not excite the sense of sight. Inconceivable as is this rapidity, these figures are not hypothetical, nor merely probable; they express absolute facts incontestably established.

Like the limits of hearing, so these limits of vision vary slightly with different individuals; some people are capable of seeing farther beyond the red and not so far into the violet, whilst the converse is true with others. Hence, beyond the shadow of a doubt, certain sounds and certain lights perceived by some persons are totally unperceived by others. And when we pass from human beings to the larger animals on the one hand, and to insects on the other, we doubtless have the range both of hearing and of vision considerably extended. We are not aware that the limits of vision in animals have ever been studied; but analogy and experience lead us to suppose that it differs from our own in many cases. Assuming that the perception of light is due to a sympathetic vibration of the filaments of the retina, it merely needs that these filaments should be capable of vibrating only the one hundred millionth of a millionth per second slower, and what we call black heat would be perceived as light: and if these filaments could vibrate the same amount faster, what we call the actinic or invisible chemical rays beyond the violet would become directly visible. Now it is highly improbable that the retina of every animal in creation should be, as it were, tuned to the same pitch as ours; and if this be so, then forces unrecognized by our senses are perceptible elsewhere.

The structure of the ear in a calf points to the conclusion

* This suggestion was first made, we believe, by Melloni, in his 'La Thermochrôse.'

that only the lowest sounds can be audible to that animal, but that its lower limit of hearing is beneath ours.* This is consistent with the doleful sounds made by that creature. Happily therefore for themselves, the lowing of cattle obviously produces a totally different impression upon their kindred to that which it produces upon us. Moreover, movements unheard by us are probably perceived as sound by them. If this be so at the lower limit of hearing, may not similar instances occur at the higher limit? It is perfectly conceivable, nay likely, that many insects produce and hear sounds far beyond our cognizance. And it would be most interesting to ascertain whether the organs of hearing in a bat, for example, or a grasshopper, correspond to the shrill sounds they produce.

Returning for one moment to the illustration of the sympathetic sounding of a piano, we find that when its strings are thrown into vibration the motion takes time to subside. Hence we should expect to find a *lingering* in our perception of both light and sound, after the exciting cause had ceased. This is exactly what occurs. The retention of light upon the retina amounts to $\frac{1}{10}$th of a second. This retention causes a luminous point in rapid motion to appear as a line; the successive impressions blend into one. We cannot perceive as distinct from each other flashes of light that succeed each other at shorter intervals than the $\frac{1}{10}$th of a second apart. Similarly our ear cannot distinguish between a succession of similar sounds that follow each other at shorter intervals than the $\frac{1}{16}$th of a second. Like the blending into one of the colours on a spinning-top, the separate sounds link themselves together and constitute a musical note.

Radiant sound and light being both wave-motions, many laws are found common to both. When light falls upon a body it is either *transmitted*, *absorbed*, *reflected*, *refracted*, or *inflected*. The same phenomena can be observed when we substitute sound for light. Let us briefly examine this remarkable series of analogies.

§ 4. Transmission of Light and Sound.

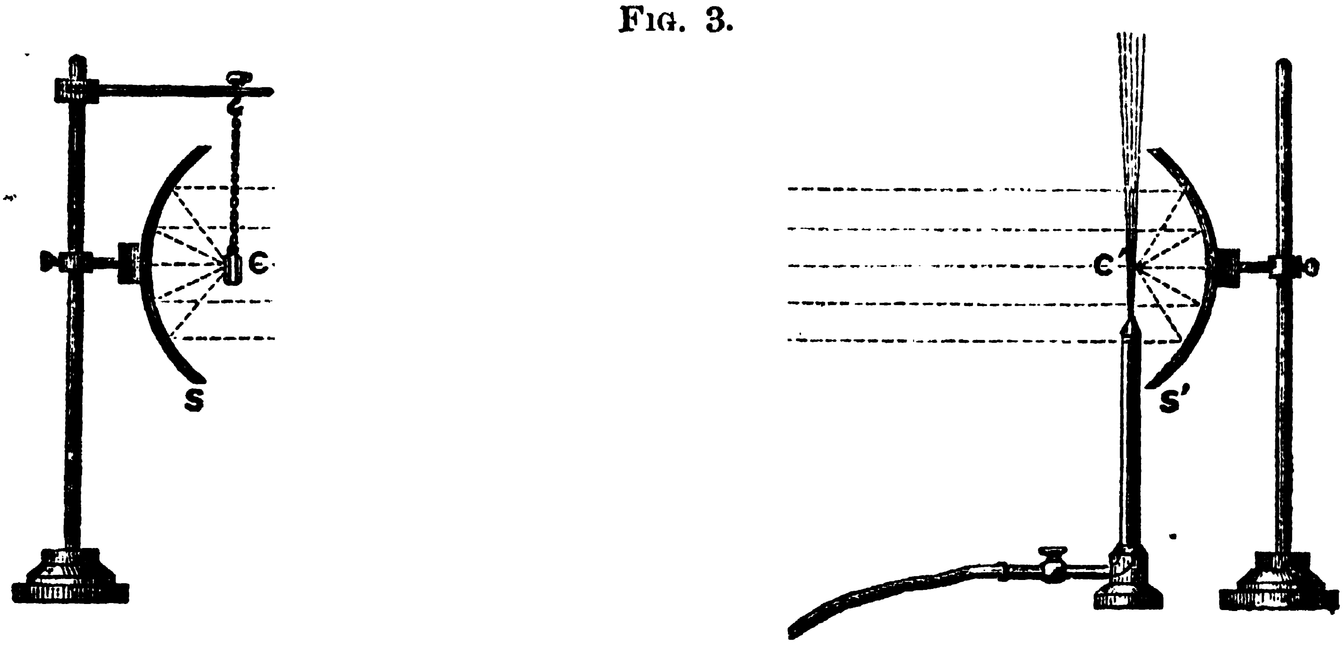
Through transparent bodies *light* is transmitted freely. But if a series of transparent substances, each alternately differing in density, be placed together, the progress of light is obstructed, and may even be altogether stopped. Thus a perfectly transparent block of glass, if reduced to powder, is perfectly opaque. Air, a medium of different density, now intervenes between the particles of glass, and the light *echoed*, as it were, from particle to particle is so weakened that it cannot struggle through.

In the same way *sound* in its passage is enfeebled, or even obliterated, if it pass through several media of alternately varying

* Savart: 'Annales de Chimie et de Physique.'

the flame are rendered parallel by s and converged upon the watch by s, where a brilliant spot of light is seen. Similarly the sound-waves from the ticking of the watch follow the opposite course,

FIG. 3.



and an acoustic focus is cast upon the flame. The flame throbs in exact time with the beats of the watch. Moving the watch or the flame nearer together places them out of the focus, and the flame by its stillness announces the fact.

It is easy for any one to repeat this experiment with very homely apparatus. Circular dish-covers of earthenware or metal may be used as mirrors, and for the flame may be substituted a little funnel with a short tube leading to the ear.

§ 7. Refraction of Light and Sound.

Light on passing from a dense medium to a rare one, or *vice versâ*, is bent out of its original course. So also is sound. Light may by refraction be converged and focussed by lenses. Sound-lenses may also be made.* Filling a thin india-rubber balloon with a dense gas, like carbonic acid, a double convex acoustic lens is produced. By means of such an arrangement divergent sound rays, from, for example, the ticking of a watch, can be converged and focussed. Placing a sensitive flame in the focus, this refraction of sound may be rendered apparent to a large audience.

§ 8. Inflection of Light and Sound.

This is an effect produced upon divergent waves merely by the presence of an obstacle in their path. When a sea-wave meets an isolated rock it breaks, spreads itself around the rock, and clasps itself again at a short distance behind. Thus only comparative rest is found behind such a breakwater. Similarly a sonorous wave meeting an obstacle, say a large pillar, girdles the pillar and thus

* As first demonstrated by Sondhauss.

partially destroys the sound-shadow which such a pillar would otherwise throw. In former time it was urged that if light be a wave-motion, there ought also to be inflection and only partial shade behind an opaque object. The inflection of light has since been discovered; light *does* slightly encroach, in the form of fringes, upon the shadow cast by an object. Nevertheless, owing to the rectilinear propagation of light, shadow is a characteristic feature of light. Is there an analogous sound-shadow? There is, notwithstanding inflection. If we pass close beside a church, the bells of which are ringing, we shall notice that on coming beneath the tower we enter a region, nearer the source of sound, yet where the sound is very perceptibly less audible; and as we gradually emerge from this acoustic shadow the sound grows louder. So also when listening to an approaching train, as it is occasionally hidden from view, accompanying sound-shadows flit across the ear. And in a more elastic medium than air, such as water, sound-shadows would, necessarily, be more intense and sharply defined.

§ 9. Harmony of Colour and Music.

It is in this division of our subject that we find a wide-spread and tacit acceptance of the analogy of light and sound. We instinctively criticize in like terms the works of a painter and a musician. We speak of the harmonious blending of colours in a picture, as we do of the chords in a musical composition. We compare, apparently without reason, the order of colours in a rainbow to the notes of the gamut. Like Locke's blind man who said scarlet was to him as the deep sound of a trumpet, we think of red as a low note, of blue as a high one. We find, as a rule, that good taste in art goes hand-in-hand with good taste in music; hence a large number of eminent painters have been excellent musicians.* All this points to the fact that pleasure given to the eye or ear evokes similar mental impressions.

Now the question arises, Has all this æsthetic oneness of colour and music any physical foundation, over and above that general analogy we have so far traced between light and sound? We believe the following considerations will show not only that it has some foundation, but that the analogy is far more wonderful than has hitherto been suspected.

Let us take as our standard of colours the series given by the disintegration of white light, the so-called *spectrum*. As our standard of musical notes let us take the natural or *diatonic scale*. We may justly compare the two: for the former embraces all possible gradations of simple colours, and the latter a similar gradation of notes of varying pitch.

* Omitting many living painters, of whom this is true, it is sufficient to name Tintorretto, Caracci, Salvator Rosa, Dominichino, Guido Reni, Leonardo da Vinci; and Rubens also is said to have been passionately fond of music.

Further, the succession of colours in the spectrum is perfectly harmonious to the eye. Their invariable order is red, orange, yellow, green, blue, indigo, violet. Any other arrangement of these colours is less enjoyable. Likewise the succession of notes in the scale is the most agreeable that can be found. The order is C, D, E, F, G, A, B.* Any attempt to ascend or descend the entire scale by another order is disagreeable. The order of colours given in the spectrum is exactly the order of luminous wave-lengths, decreasing from red to violet. The order of notes in the scale is also exactly the order of sonorous wave-lengths, decreasing from C to B.

The interval of wave-lengths embraced between the extreme colours of the visible spectrum is ordinarily as the ratio of 1:0·57, corresponding to the interval known as a seventh in music. But the writer is well informed that by proper means further limits can be seen, *viz.* from what is known as the solar line A to the solar line L.† (See upper figure in Plate: L is not shown.) The wave-length of A is 76, and of L is 38 hundred-thousandths of a millimètre, or as the ratio of 1:0·50, corresponding to the interval of an octave in music, or just the range of the scale.

Arbitrarily placing C under the colour at the solar line A, *viz.* a deep brownish red, then the octave higher of C would fall under whatever colour is found at the solar line L, *viz.* a lavender grey. Now comes this important question, *Are the intermediate colours of the spectrum produced by vibrations that bear a definite ratio to the vibrations giving rise to the intermediate notes of the scale?* According to our knowledge up to this time, apparently not.

In an ingenious little work by Dr. Macdonald, before alluded to, an attempt has been made to establish this analogy indirectly;‡ but if direct comparison fails, it is useless to push the matter farther. Newton himself sought for this analogy between note and colours, but he only found the relative spaces occupied by each colour in the spectrum to be similar to the relative intervals of musical notes. This is, obviously, a false analogy. We must compare wave-lengths of light with wave-lengths of sound; not, of course, their actual lengths, but the *ratio* of one to the other.

Until very recently it has been impossible to do this accurately. New maps of wave-lengths of the different parts of the spectrum have, however, of late appeared.§ Let us reduce the newest and best determinations of wave-lengths to a common ratio, and com-

* The fact that Newton saw seven colours in the spectrum, and there are seven notes in the scale, is only an accident; the number of colours, or tints, entirely depends on the judgment of the observer.

† This is on the authority of Mr. Crookes, who has on favourable occasions seen the spectrum extending this length, where a quartz train of lenses and prisms was employed.

‡ It is a pity this brochure of Dr. Macdonald's is so disfigured by its typography, it is also too speculative and dogmatic.

§ The most recent by Thalen. 'Transactions of Royal Society of Upsala,' 3rd Series, vol. vi.; also 'Annales de Chimie et de Physique,' Oct., 1869.

pare the result with the wave-lengths of the notes of the scale reduced to the same ratio. Here are the limits of wave-lengths of the different colours of the spectrum as most carefully determined by Prof. Listing.* In the third column the writer has added the mean wave-length of each colour, and in the fourth column the ratio of one colour to another, taking the mean wave-length of red as 100.

TABLE OF WAVE-LENGTHS OF COLOURS IN THE SPECTRUM.

WAVE-LENGTHS: IN MILLIONTHS OF A MILLIMETRE.

Name.	Limit.	Mean.	Ratio.
Red	723 to 647	685	100
Orange	647 to 586	616	89
Yellow	586 to 535	560	81
Green	535 to 492	513	75
Blue	492 to 455	473	69
Indigo	455 to 424	439	64
Violet	424 to 397	410	60

Here next is a table giving the middle notes of the scale, their wave-lengths, and their reduction to a common ratio, taking C as 100.

TABLE OF WAVE-LENGTHS OF NOTES OF SCALE.

Name.	Wave-length in inches.	Ratio.
C	52	100
D	$46\frac{1}{3}$	89
E	42	80
F	39	75
G	35	67
A	31	60
B	$27\frac{1}{2}$	53
C_2	26	50

Putting together the two ratios, the following remarkable correspondence at once comes out:—

RATIO OF WAVE-LENGTHS OF NOTES COMPARED TO RATIO OF WAVE-LENGTHS OF COLOURS.

Notes.	Ratio.	Colours.	Ratio.
C	100	Red	100
D	89	Orange	89
E	80	Yellow	81
F	75	Green	75
G	67	Blue and indigo (mean)	67
A	60	Violet	60
B	53	[Ultra violet	53]
C	50	[Obscure	50]

Assuming the note C to correspond to the colour red, then we find D exactly corresponds to orange, E to yellow, and F to green. Blue and indigo, being difficult to localize, or even distinguish in the spectrum, they are put together: their mean exactly corresponds to the note G. Violet would then exactly correspond to

* Poggendorff's 'Annalen,' vol. cxxxi., p. 564.

the ratio given by the note A. The colours having now ceased, the ideal position of B and the upper C in the spectrum are calculated from the musical ratios. This coincidence, as unexpected as it is perfect, is represented in the two upper figures on the Plate.*

Had space permitted, we should have ventured to trace out to some extent this common harmony of colour and sound. All we can do is to point out a few suggestions that occur at once.

Every one knows that the juxtaposition of two colours nearly alike is bad, and it is well known that two adjacent notes of the scale sounded together produce discord. Selecting and sounding together two different notes we may produce either discord or harmony; so with the juxtaposition of certain colours, either pleasurable or painful effects are produced. Thus—the notes D and E, together, are bad; so are orange and yellow when contrasted. C and G harmonize perfectly, so do red and blue. C and F is an excellent interval, so is the combination of red and green. Now, on referring to the Plate, it will be seen that the foregoing notes exactly underlie those very colours that we have named with them.

But, further, it is possible to obtain a real optical expression of the musical intervals.† By reflecting a beam of light from one vibrating tuning fork to another placed at right angles, curves of light are obtained, which vary according to the combination of forks we select. The most perfect harmony, *viz.* two notes in unison, gives the simplest curve—a circle. The next most harmonious interval, an octave and its fundamental note, gives the figure of 8; the next, the interval of a fifth, gives a more complete figure, and so on. The complexity augmenting as the concord lessens. Some of these curves are shown on the lower figure in the Plate. By the side of each curve is put the musical notes from which it was derived, and for the sake of comparison the colours which would correspond to each interval are also brought down. It will be seen that harmony runs throughout.

A musical chord thus becomes both a representative picture, and an acoustic painting, whilst the musical scale is literally a rainbow of sound. It is hardly too much to say that we might possibly translate into a musical melody a sunset, a flower, or a painting by a Rubens or a Raphael.‡

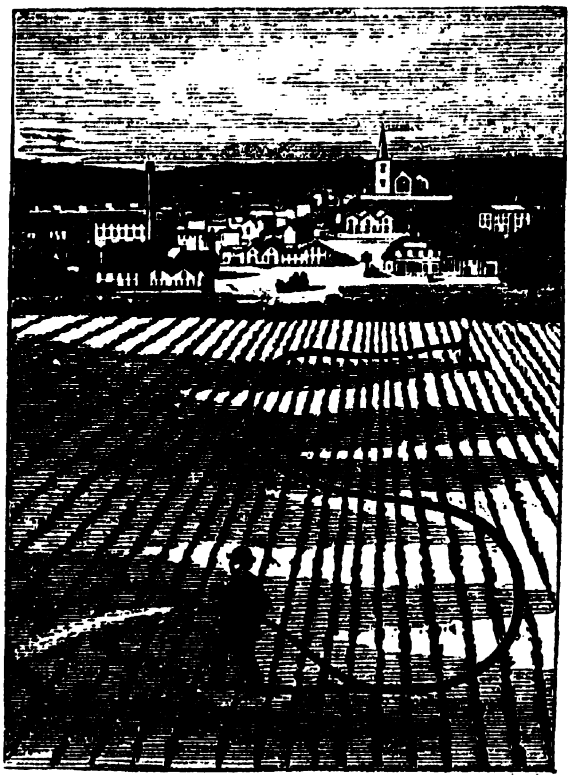
But here let us check our imagination. We have throughout the foregoing article endeavoured to avoid overstating the analogy. Let us now be careful lest we become victims of the "*idola tribus,*" lest we strive to impose on nature a greater degree of simplicity than her facts will justify.

* There will be noticed over the spectrum on the Plate a scale of actual wave-lengths, by which the remarkable but natural crowding together of the colours at the red end is well seen.

† First accomplished by M. Lissajous.

‡ On this subject an able article by Mr. C. Seth Smith, recently appeared in the 'Builder.'

II. ON THE PRINCIPLES AND METHODS OF SEWAGE IRRIGATION.



SEWAGE utilization is perhaps one of the most hotly-debated subjects of the day, and frequent references to it have from time to time appeared in the pages of this Journal. These will be found repeatedly in the Chronicles of Science (Agriculture), and in two articles, entitled respectively "Sewage and Sewerage,"* and "On the application of Sewage to the Soil,"† wherein the progress made in the development of works for sewage irrigation purposes has been recorded. Our present object is to give a brief account of the best means for carrying out irrigation works for the disposal of town sewage, and of the laying out of lands preparatory to the application of sewage, so far as they can be deduced from the results of past experiments, and from works hitherto constructed and brought into operation in different parts of the United Kingdom. We shall, however, preface our remarks on the above-named subjects by a reference to one or two points in connection with them, with the view to show that the present movement in favour of utilizing our town sewage is but the revival of a practice of great antiquity, which, owing to numerous causes, has, for many centuries, been abandoned and perhaps forgotten.

The recognized power of earth to act as a disinfectant may first be traced to the Mosaic lawgiver, but it is not improbable that it was applied to that purpose before the departure of the Israelites from Egypt, and that the injunction for it to be so used whilst they were on their wanderings was but a law for the observance of a then well-known sanitary precaution. The filth of Jerusalem was, it is recorded, at one time burnt in an oven in the valley of Hinnom, which also served for human sacrifices, and was called "*tophet*," from "*toph*," a drum, used on such occasions to drown the cries of the victims. At a later period, however, when the Mosaic religion was restored, the Temple purified and rebuilt, and the country began to prosper under the protectorate of powerful neighbouring nations, large sewers and aqueducts were constructed, which still exist, owing to the fact of their being cut in the solid rock upon which the city was built. Eusebius, who was a native of that country,

* 'Quarterly Journal of Science,' 1866, p. 180. † Ibid., 1867, p. 357.

and died about the year 340, mentions Timocrates, the surveyor of Syria, by whom the city was throughout provided with water. The water used for flooding the court of the Temple, to wash away the offal and blood of the sacrifices, drained into a pit, now called "The Fountain of the Virgin;" from whence, after mingling with the town sewage, it was conducted to a second one, now called the Pool of Siloam—but which, it is thought, is not the one formerly known by that name— and thence to the king's garden, for purposes of irrigation. These pits served, no doubt, as settling-tanks to collect the solid matter; and thus, in their general arrangement, we can perhaps trace the earliest recorded attempts at utilizing sewage, and one which, so far as our information goes, does not appear to have differed materially from the most approved practice of the present day.

The difficulty in getting rid of night-soil and refuse in large towns by any other method has necessitated the adoption of sewers and water-carriage for that purpose, and with our present knowledge on the subject it does not appear probable that sewers will ever be superseded. "It matters not," remarked Mr. Bailey Denton in a recent letter to 'The Times'* newspaper, "whether the earth-closet system of excretal sewerage gains ground in places where advantageous circumstances suggest its adoption, sewers must exist in every place where habitations are congregated together, whether it be a city or a village, for the discharge of liquid refuse from the chamber, the bath, and the kitchen, independently of the excrements of the closet, which form in reality but a small proportion of the entire refuse of the dwelling." The introduction of sewers in places has, as might naturally be expected, led to their being used also as drains, and the result appears to have been satisfactory, although the reports by the Medical Officer of the Privy Council tend to show "that where a system of separating the sewage of dwellings from the water of the soil on which they stand has been adopted, and the sewerage and drainage can be discharged by different channels, the maximum of success may be achieved." On the other hand, Mr. Denton states that "wherever sewerage and drainage—which have different sanitary effects, and ought to be distinct operations—have not been carried out together, intentionally or accidentally, the operations have failed, more or less, in the purposes for which they were designed."

The mixture of water with sewage is looked upon by some agriculturists as a great drawback to its application. Apart, however, from water-carriage being the cheapest, as well as the most convenient form of removing the sewage of towns, it is of value in distributing it, and enables the operation of spreading solid manure over the face of the earth, which must otherwise take place, to be

* 'Times,' October 28, 1869.

dispensed with. By the process of irrigation, too, fertilizing matter is distributed over the land with uniformity, and it is presented to the plant in such a state that it is at once ready to be assimilated, that is, it is at once food for the plant; the plant grows more rapidly, the period of growth is greatly shortened, and, consequently, we get a greater number of crops in a given period, under the irrigation system, than could possibly be obtained under any process of dry manuring. The quantity of water mixed with the solid matters in the ordinary sewage of towns is very great, and it has been estimated that, including rainfall, 350 parts of water are employed in removing one part of excrement; thus the sewage is delivered to the land in a very diluted state, but, as has been proved by results, by no means too weak for useful application. The strength of pure sewage would be far too much for vegetation, and, instead of improving it, would tend utterly to destroy it; but thus diluted it is reduced to a state in which it appears to be most readily absorbed by the earth, and thence taken up by plants as it is required for their nourishment.

In order to meet the requirements of local circumstances, where land is not available for purposes of irrigation, attempts have from time to time been made to separate the solid particles from the fluid, the former being made into a species of artificial manure, whilst the latter is allowed to pass away into the most convenient channel for its escape. The value of the manurial ingredients held in solution, being to that contained in the solid portions as six to one, the great fertilizer ammonia also being afloat in the liquid portion, it is not to be wondered at that these experiments have invariably failed, and the works erected for carrying out the different processes have, almost without exception, been abandoned. After filtration, the general plan has been to mix the solid residuum with dry rubbish, town ashes, charcoal, or other bases for forming a solid substance; the unwillingness, however, of farmers to purchase this manure at a remunerative price to the manufacturers, and often their refusal to pay for it at all, necessarily led to the early closing of all works constructed for the purpose of its manufacture.

In order to counteract the loss of valuable manurial ingredients which, under the above processes, passed off with the liquid portions of the sewage, recourse was next had to the use of chemical reagents with the view of causing a precipitation of those fertilizing ingredients which are held in solution, and for this purpose use has been made of lime, sulphate of alumina, soluble phosphate of magnesia, perchloride of iron, &c.; but as none of these have been successful in causing a precipitation of ammonia, or any other manuring substance, it is needless to enter here into any further details regarding these experiments. Suffice it to state that no

attempt hitherto made to extract a useful manure from sewage which could be applied in a solid form has proved anything but a failure.

The Commission appointed by the British Association to report "On the Treatment and Utilization of Sewage," states, with reference to the treatment of liquid sewage, that at fifteen of the places which are sewered, wholly or partially, the liquid sewage is subjected to treatment either by allowing it to remain for a time in settling-tanks, from which the deposit is occasionally removed, as at Burton-on-Trent, Birmingham, Epsom, Farnham, and Andover, or by filtering, as at Uxbridge and Ealing. In eight instances deodorizing materials are added, such as lime and carbolic acid, as at Carlisle and Harrow. Lime alone is used at Leicester; lime and chloride of lime at Luton; perchloride of iron at Cheltenham; perchloride of iron and lime at Northampton; ferruginous clay wetted with sulphuric acid at Stroud; and at Leamington the lime treatment has lately been superseded by the A, B, C, method proposed by Messrs. Sillar and Wigner. By this treatment the sewage is clarified, and a deposit is separated which is sold as manure.

In regard to the effects thus produced, it is stated that at Leicester the sewage runs off as pure as ordinary rain-water; at Ealing it is said to be free from smell, colourless, and harmless to vegetable or animal life; at Stroud and Luton the effect is stated to be satisfactory; at Harrow the nuisance is said to be somewhat mitigated; and at Abergavenny the stench is said to be abated by the treatment of the sewage; at Bury St. Edmunds upward filtration through charcoal and gypsum has been abandoned in favour of costly irrigation; at Banbury treatment of the sewage has failed; at Hereford, where it was proposed to be adopted, it has not been tried on the score of expense; at Tunbridge it is about to be tried; and at Hastings and Cambridge experiments are being made.

With regard to the relative advantages of solid and liquid manure, supposing even that all the fertilizing properties of sewage could be retained in a solid form, we cannot perhaps do better than to quote the following extract from the 'Minutes of the General Board of Health relating to Drainage and Sewerage of Towns, &c., 1852,' by whom the question seems to have been satisfactorily set at rest:—"It is established by wide general experience that drained land does not deteriorate, but increases in fertility, and maintains its increased fertility from year to year, though washed through and through by all heavy falls of rain carried away by the drains. The rationale of this fact was displayed in the experiments prosecuted by Professor Way, which show that upon the application of manures in the liquid form the fertilizing elements do not escape through the soil, but are retained by it chemically. On the other

hand, where manures are applied as top-dressings in the solid form, it is proved by experience that after heavy showers of rain the solid manure is washed away, bodily as it were, into the ditches and watercourses; so that whilst the outfalls from land top-dressed and undrained are turbid with the matter carried away, and complained of as a nuisance, the outfalls from drained land, richly manured with the liquid, discharge pellucid streams."

Liquid sewage has a special value distinct from the fertilizing matter it contains, and also from the water that transports it; and this is its temperature. The value of this peculiar property cannot be over-estimated in a country similar to this, in which extreme changes of atmospheric temperature often take place suddenly, and injuriously affect both plants and animals, and this is more particularly demonstrated in the depth of winter and during long and continuous frosts. "It is a rather remarkable circumstance," observes Mr. Baldwin Latham, "that when the greatest degree of temperature is required the sewage possesses it, that is, the temperature of sewage has been found by the author to increase with the period of duration of frost. This is probably owing to the stagnation of surface-water, and also to the habits of the people, as much less cold water is used in the depth of winter than at other times. So great is the value of temperature, that a crop under sewage irrigation may be seen growing even at the time of a severe frost."

It does not appear that there exist any soils to which sewage irrigation may not be beneficially applied. That portion of the Craigentinny Meadows at Edinburgh known as Figgate Whinns, consists of absolutely pure sand, whilst the soil of other parts is a good loam passing into a strong clay; the former, which was originally worthless, now produces grass crops which sell at from 20*l.* to 28*l.* per acre per annum, thus showing that no land can be too poor for profitable cultivation where liquid sewage is obtainable in sufficient quantity. A larger amount of sewage is required for light than for heavy soils, particularly during the first year of its application; and clay appears of all others to possess the peculiar property of separating the manurial ingredients more completely, and of retaining them better, than any other soil, and it is consequently found that the crops grown are much heavier, and that altogether clay soils produce a far better result than those of a light, sandy nature. Gravelly soils require a certain time to become thoroughly saturated with the sewage, and absorb it greedily while the operation is in progress.

The value of a good system of drainage in all agricultural land is sufficiently understood at the present day; but if it be beneficial under ordinary circumstances, it is absolutely necessary where irrigation is adopted, especially in heavy soils. "I have no doubt," says Mr. Denton, in the letter above referred to, "that in cases of

sewage applied by way of irrigation to the surface of undrained clay land, or to water-logged free soil lacking natural drainage, the earth will become sodden, and liable to create a malaria; but with a perfect system of under-drainage (designed with relation to surface irrigation) at the first description of soil, and natural drainage in the second, sewage-irrigated land may be rendered perfectly harmless." From time to time complaints have been raised that land irrigated with sewage-water was offensive to the surrounding neighbourhood; the observations of the British Association Commission, however, tend to prove that in most cases the application of the sewage for irrigation has not been attended with any apparent change in the sanitary condition of the district, whilst in several instances there has been a marked improvement. Generally speaking, too, no objection appears to have been made to the application of sewage in this manner, and where such objections have been made, on the ground that the application was offensive and injurious, they do not appear to have been supported by medical authorities, and in several instances they have ceased.

The quantity of sewage that may be applied with advantage to an irrigated area in the course of the year has been closely investigated by Mr. Latham, and as the results of his calculations agree entirely with the experience obtained at Croydon, and with the experiments made by the Sewage Commission, we give them here as being probably the closest approximation to exactness yet obtained. Where it is considered desirable to apply as much sewage as will be sufficient for the growth of a grass crop, without drawing on the resources of the soil, 3645 tons of sewage per acre per annum will be required to grow 30 tons of grass, 4860 tons of sewage for a crop of 40 tons of grass, and 6075 tons for one of 50 tons of grass. If, however, the soil will provide half the potash required, then, to grow 30 tons of grass per acre, there will be required 1837 tons of sewage; to grow 40 tons of grass per acre, 2450 tons of sewage; and to grow 50 tons of grass per acre, 3062 tons of sewage. As 40 tons of grass per acre may be considered as easy of production on a properly-regulated irrigated area, and as it would not be desirable to exhaust the soil of any of its constituents, Mr. Latham considers that 4860 tons per acre may be said to be the right amount of sewage, and this closely assimilates with the conclusions arrived at by the Sewage Commission, who reported that 5000 tons of sewage per acre per annum was the right amount to apply in order to get the greatest results.

The actual value of town sewage yet remains, to a certain extent, an open question, but it may be accepted as a universal rule, that only under the most exceptionally favourable circumstances can the sale of it afford any adequate return upon the cost of constructing sewage works; so that, however profitable its use

may be to the farmer, it cannot be relied upon as a source of much income to the town whence it is obtained. The theoretical value of sewage has been calculated by some of our most eminent chemists and others, and the results arrived at vary from 1*d.* to upwards of 2*d.* per ton. Practically, however, it has been found that this is too high, and that its real value—that is to say, the price which a farmer could afford to pay for it—does not exceed from ½*d.* to 1*d.* per ton, and in estimating the probable returns from the sale of sewage it will always be safer to adopt the lower figure.

The cost of the application of sewage for irrigating land appears to be dependent on a number of local conditions, and, consequently, to vary considerably. It would seem, from the data collected by the Commission appointed by the British Association, that in many instances the outlay requisite for this purpose would exceed what a farmer could be expected to incur, and that in such cases, at least, it would be proper to regard this outlay as coming under two distinct heads, *viz.* that which a town may reasonably be expected to bear for the mere object of getting rid of its refuse, and that which a landowner or farmer may be able to incur for the improvement of his land. It is probable that when viewed in this light the application of liquid sewage to land would become a source of revenue to towns only under special favourable circumstances, but that, in opposition to the opinions which have been somewhat hastily formed in certain cases, it will more frequently entail some amount of expenditure on the towns themselves. At the same time the benefit to land and the improvement in the condition of rivers to be realized by this mode of dealing with liquid sewage can scarcely be matter of doubt or uncertainty any longer.

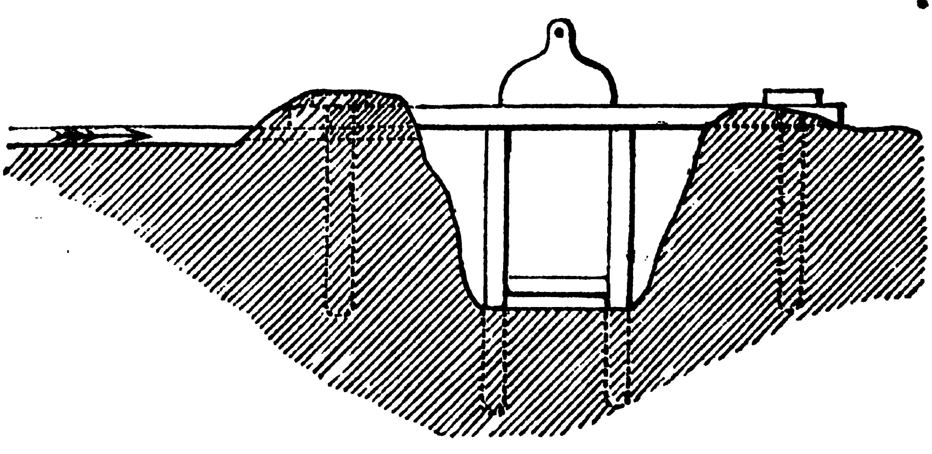
For carrying out a system of irrigation it is necessary, of course, that the sewage should, in the first place, be brought by channels or drains to the neighbourhood of the fields to be irrigated, where the more solid parts are separated from the liquid by allowing it to settle for a time, or, as is more generally the case, by a coarse system of filtration. For the distribution of the liquid, four different methods have been applied, *viz.:* 1. That known as the hose and jet system. 2. Sub-irrigation, or the distribution of the fluid below the surface of the ground. 3. By means of surface channels. And, 4. By total submersion. In deciding, however, which is the best system for distributing sewage, two things should be kept in view: the first is that all arrangements for its distribution should be as simple and inexpensive as possible; and the second, that owing to the constant quantity of sewage to be dealt with, the arrangements must be capable of being worked at all times and seasons. With these preliminary remarks we proceed now to describe briefly the principles upon which the different methods of distribution, above referred to, are carried out.

1. *The Hose and Jet System.*—The fatal objection to this system is that it is not capable of application at all seasons. In laying out works for the purpose, the sewage must, in the first instance, be brought into the field by means of underground pipes, which must also be laid in a sort of network over the whole grounds to be manured, to which pipes with couplings or hydrants for attaching a hose are fixed at certain points (see Vignette). In all cases where the hose and jet system is applied, the sewage must be delivered under pressure to enable it to be distributed over the field at a considerable altitude above its surface, as well as to overcome the friction in the pipes, and a head of from 10 to 12 feet is necessary where the sewage is delivered by the force of gravitation. Where a natural fall cannot be obtained, pumping becomes necessary, and this adds considerably to the cost. One great objection to the hose and jet system is that sewage cannot be applied to crops by it except at the earliest stages of their growth, owing to the necessity for dragging long lengths of hose over the land; it is therefore quite inadmissible when the crop has grown to any considerable height. Besides, by this mode of application the sewage is sprinkled over the crops, falling upon them as a shower, instead of being applied to the roots, which, though it would be unimportant and harmless were pure water only used, becomes actually injurious to vegetation in the case of sewage irrigation, by leaving certain deposits upon the leaves and stems of plants, which clog their pores and check growth. The system has enjoyed a partial success on the farms of Mr. Alderman Mechi and Mr. Nelson, but at Rugby, and other places, it has totally failed, and been abandoned. Mr. Rawlinson has stated that it would cost more to distribute 500 tons of sewage per acre by the hose and jet than it would to apply 5000 tons by surface channels.

2. *Sub-Irrigation.*—Under this system porous pipes, or tubes perforated with small holes, are laid under the ground at such a depth as to be beyond the reach of the plough, through which the sewage-water is forced. In some instances the pipes that are used for drainage may be made use of for this purpose by merely stopping up their outlets during the time that they may be required for irrigation, by which means the water will be dammed back until it reaches the upper stratum of the earth and the roots of the plants. This system has been practised in Switzerland to a limited extent; it is, however, expensive, and is open to the objection that it tends to raise the water in the land to the level of the soil, and the earth thus becomes water-logged, in addition to which it is attended with a great waste of fertilizing matter owing to the depth at which the sewage is delivered below the surface, a part of it gravitating still lower into the earth, and only a portion reaching the roots of the plants.

3. *Surface Channels.*—For the purpose of distributing sewage by means of open carriers, or surface channels, it may, if desirable, be brought to the head of every field in a covered channel, or it may be permitted to flow through open ditches, as may be most convenient. This system, which is the simplest and most effectual, may be carried out in various ways, according to the configuration of the land. By it sewage can be at all times applied to the plant, as it merely runs in a thin film over the surface of the ground at its root; but in all cases it is necessary that the land be specially prepared for the sewage by careful levelling, and otherwise according to its natural contour. This may be done in three ways, which are respectively known as the pane and gutter system, the catchwork system, and the bed system. The pane and gutter system is the best, and is admissible in all fields having a gentle rate of inclination. The land under this system is laid out, transversely between the open carriers that distribute the sewage, quite level; the sewage is brought to the head of the field in an open or covered main carrier running transversely across it, or in the direction of its least fall; the carriers for distributing the sewage branch out from the main carriers and run down the field in the direction of its greatest fall; the sewage is distributed over the intervening space between the distributing carriers by means of stops or sluices (see Fig. 1) being placed in the carriers, which dam back the

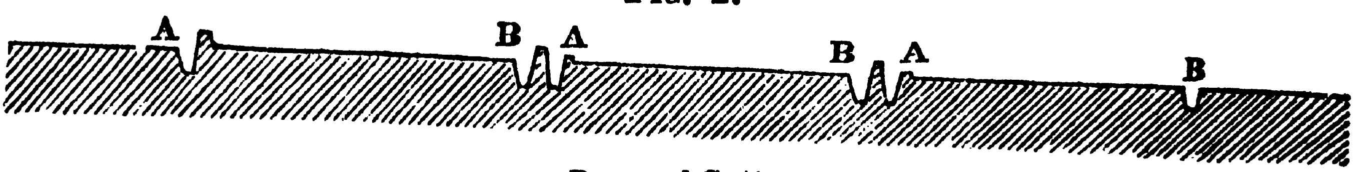
Fig. 1.



sewage and make it flow right and left over the ground in a uniform stream.

The sewage passes from the main carriers into the secondary

Fig. 2.



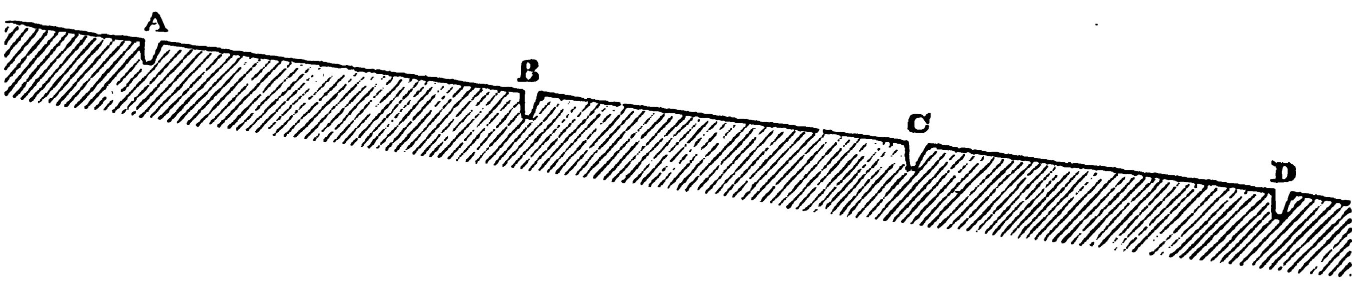
Pane and Gutter.

carriers at A (Fig. 2), which being dammed up at certain points are caused to overflow, the surplus water being carried away by the

discharging drains B. A fair slope for this plan is from 1 in 100 to 1 in 120, or thereabouts.

The catchwork system is suitable in all cases where the ground has a rapid rate of inclination, as, for instance, on the side of a hill. It consists of a series of carriers one above another, as illustrated in Fig. 3. The sewage, flowing into the first and highest carrier, falls over the intervening land between it and the next lower carrier, which then takes up the water to distribute it in the same way on the land below it, and so in turn the process goes on till the bottom of the field is reached.

FIG. 3.



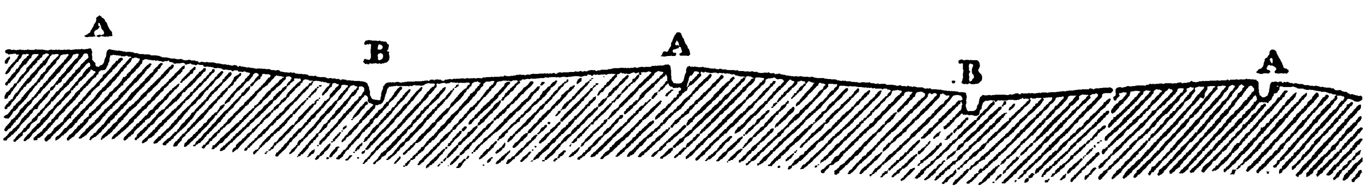
Catchwork.

The sewage is first received at A, and flows over the ground to B, thence to C, and it is finally conveyed away by the trough or carrier D. The carriers in this case may be cut at a distance from each other of from 35 to 40 feet. As to the slope itself, 1 in 12 would be found a good limit, although 1 in 4 or 5 has not been considered too steep.

The bed system is well adapted for level lands, or where there is but a slight fall. On this plan the land is laid out in a series of ridges and furrows; the sewage is admitted into carriers which run along the summit of each ridge, and falls over the incline into the furrow below. This will be readily understood from the annexed plan and description, Fig. 4.

A represents the ridge carriers which receive the sewage from the main carriers, running at right angles to them at the head of

FIG. 4.



Ridge and Furrow.

the field, and B shows the carriers in the furrows which are connected with the discharging drains. The sides of the slopes are carefully levelled to an inclination of about 1 in 120, and the ridges may be placed at an average distance of from 30 to 80 feet apart, according to the crop put into the ground.

4. *Total Submersion.*—The method of carrying out this system is by raising a bank round the field to be irrigated, and then turning the water into it, where it is left until absorbed or evaporated, being from time to time replenished as may be necessary. It is extensively carried out in Piedmont and Lombardy in the cultivation of rice, and, unlike any other, it is the only system of irrigation that is considered likely to affect the health of the inhabitants in the immediate neighbourhood of its operation, its special drawback being that it converts every field where it is practised into a swamp of the worst possible description.

In conclusion, we may give the following short particulars regarding the selection of crops to be cultivated by sewage; on this point, however, more experience is required, as, owing to the greater facility by which it can be applied to grass, but few experiments have been made for its use with other crops. Fast growing, succulent grasses appear to be the favourite crops, and especially Italian rye-grass, of which crops varying from 30 to 50 tons to the acre may be obtained annually; and on one occasion as much as 61 tons were obtained in the year at the Lodge Farm, Barking. At Rugby some experiments have been made in the growth of oats, and the results reported to be of a most satisfactory nature. At Barking a couple of roods of land were ploughed up, irrigated with sewage, and sown with wheat; whilst a similar quantity of land, not irrigated, was also sown. The yield of the sewaged land was exactly 1½ time that of the land which was not so treated. Mangold wurzel has been grown with excellent results at Chelmsford, and at Barking the average return has been 50 tons per acre, just double that grown upon unsewaged soil. Winter greens, lucerne, beet, flax, celery, and cabbages have all been grown upon the farm at Barking, and have produced returns beyond all expectation, the onion being the only plant that evinced any repugnance at being treated with sewage.

Experience has now shown us that town sewage is not a refuse, and that allowing it to fall into the nearest rivers, or into the sea, is nothing more nor less than wilful waste, to such an extent as to amount to a national loss, to say nothing of the consequent diminution of food which ensues by the destruction of fish. Few towns are so situated as not to be able to dispose of a portion, at least, if not the whole of their sewage upon adjoining lands, and where this is the case no more economical plan for getting rid of it has yet been devised. Where such accommodation is wanting it may be found necessary to have recourse to some one or other of the artificial means of deodorization to which we have already referred; for although attempts to extract, by this means, a really valuable solid manure have hitherto proved unsuccessful, it would be unreasonable to draw the conclusion that means will not, sooner

or later, be discovered whereby all the fertilizing properties of town sewage may be separated from the water, and made available for disposal in the shape of solid manure.

The following is a list of the works referred to in the foregoing article:—

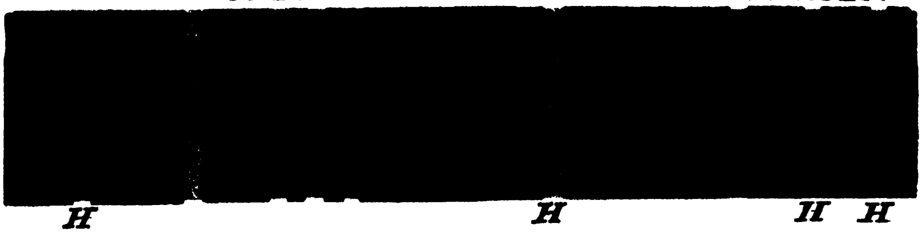
1. *Reports of the Commission appointed to inquire into the best mode of distributing the Sewage of Towns, and applying it to beneficial and profitable uses, dated March,* 1858, *August,* 1861, *and March,* 1865. Printed by Parliament.
2. *Reports of the Commissioners appointed to inquire into the best means of preventing the Pollution of Rivers, dated March,* 1866, *May and August,* 1867. Printed by Parliament.
3. *Lectures on Drainage, Sewage Irrigation, Water-supply, and Water-works, delivered at the Royal Engineer Establishment, Chatham, during the Autumn Session of* 1867. By Baldwin Latham, C.E.
4. *The Sewage Question.* By Frederick Charles Krepp. London: Longmans, Green, & Co., 1867.
5. *The Purification and Utilization of Sewage.* By Baldwin Latham, C.E. London: E. and F. N. Spon, 48, Charing Cross, 1867.
6. *Sewage, and its general Application to Grass, Cereal, and Root Crops.* By Thomas Cargill, C.E., &c. Robertson, Brooman, and Co., 166, Fleet Street, London, 1869.
7. *A Short Account of the Modes of Sewage Disposal in some of the Chief Towns in England.* By Capt. T. F. Dowden, R.E., 1869.
8. *Report on the Treatment and Utilization of Sewage by Commission appointed by the British Association,* 1869.

III. THE TOTAL SOLAR ECLIPSE OF AUGUST LAST.

By William Crookes, F.R.S., &c.

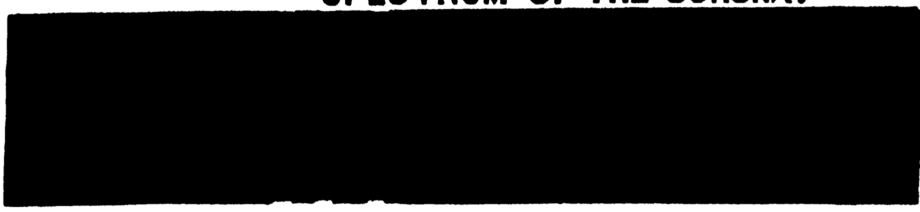
The important observations which were made last year with the spectroscope, polariscope, and photographic camera caused the total solar eclipse which took place on the 7th of August, and was visible over the greater part of North America, to be regarded with more than ordinary interest, as it was anticipated that the few minutes' opportunity then afforded would enable several points left doubtful last year to be satisfactorily cleared up.

SPECTRUM OF THE PROTUBERANCES.



PROF^R YOUNG.

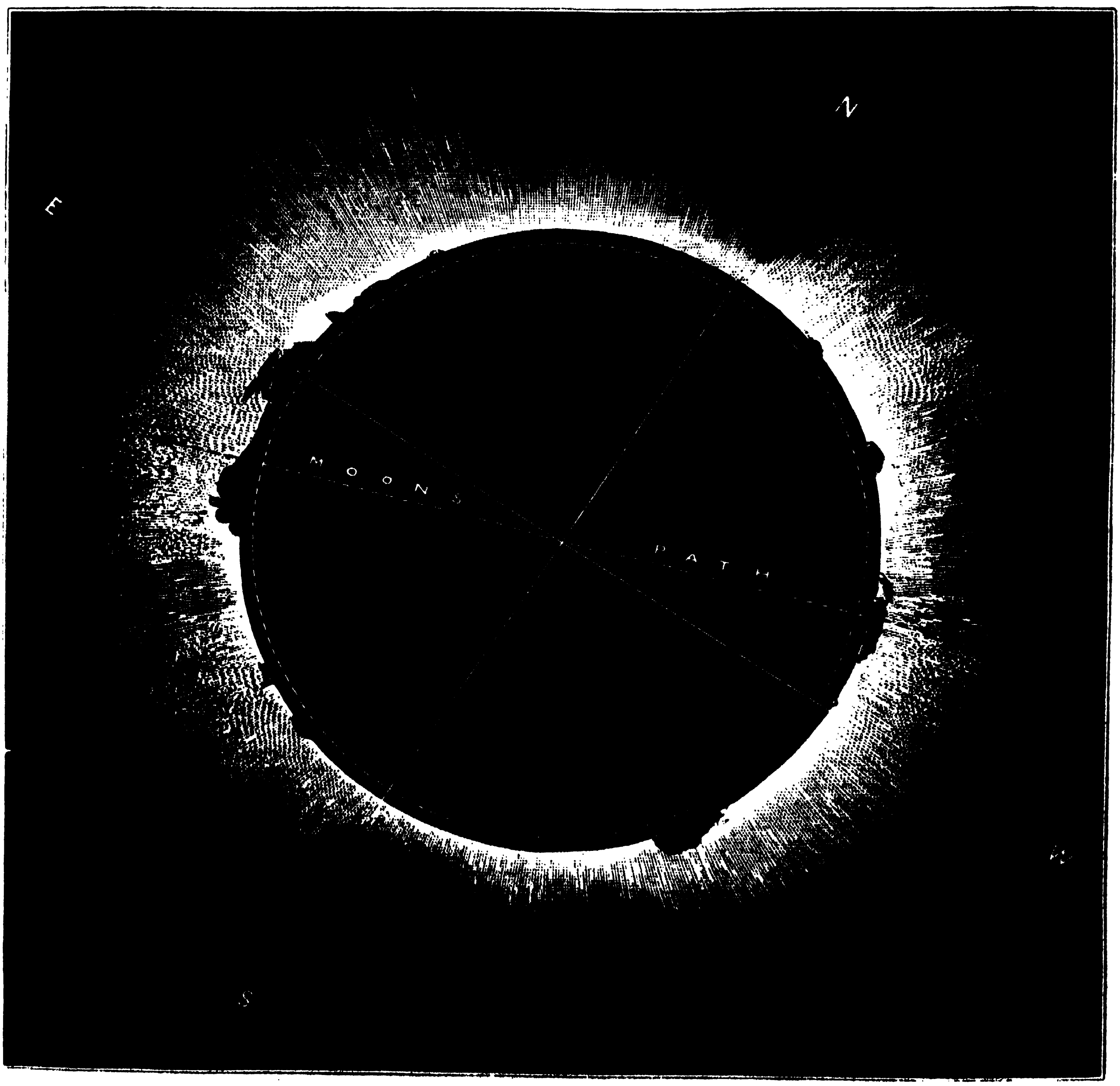
SPECTRUM OF THE CORONA.



PROF^R. YOUNG.

SPECTRUM OF THE AURORA BOREALIS

M^R WINLOCK.



THE TOTAL SOLAR ECLIPSE OF 1869.

Commencing at noon in Alaska, the line of totality ran through British America, passing through the south-west corner of Minnesota diagonally through Iowa, crossing the Mississippi near Burlington, thence through Illinois, West Virginia, and North Carolina, and entering the Atlantic Ocean on the North Carolina coast, near Beaufort. The path of the eclipse through the more inhabited parts of the continent literally bristled with telescopes; the whole line being converted into one vast observatory. Although the duration of totality was less than in India last year, the circumstances were more favourable for observation, the heat being less and the position of the sun more convenient for observation, instead of being almost vertical. The principal points which had to be observed were the nature of the protuberances, examined with the spectroscope and recorded photographically; the nature of the corona; and the detection, if possible, of any intra-Mercurial planet. As might be expected from the easy accessibility of the entire line of totality, this eclipse has been most thoroughly observed by numerous parties, the report of whose work will in due time be presented to the scientific world.

The most important observations were those recorded by the Iowa expedition, towards the expenses of which 5000 dollars had been voted by Congress. The writer has to thank his friend, Dr. Henry Morton, Professor of Chemistry in the University of Pennsylvania, who had the superintendence of this expedition, for full details of the results obtained, together with some exquisite photographs of the phenomena of totality, &c. These pictures show, in the first place, very fine definition in the telescope employed, as the roughness or mountainous character of the moon's edge is clearly given in the pictures of partial phase, as well as the sun-spots and surrounding faculæ.

The telescopes which were available for the purpose were two fine Munich Equatorials, of 6 inches aperture, with clockwork, and also an excellent Dolland, of 4 inches aperture, equatorially mounted, but without clockwork. It was concluded that on account of the risk of local clouds it would be desirable to take all these instruments, and distribute them over some distance on or near the central line, and it was also considered that at least five skilled operators would be necessary to each instrument. The next important point was the choice of the party, and it was soon found that an excellent selection might be had from among those whose position or engagements would allow them to volunteer without other compensation than the moral one contingent on success; and after a few changes, rendered necessary by sickness or other inevitable cause, the party as finally constituted consisted, besides Professor Morton, of Professor A. M. Mayer, Ph.D.; Professor C. F. Himes, Ph.D.; Messrs. J. Zentmayer, O. H. Willard,

E. L. Wilson, H. C. Phillips, E. Moelling, J. C. Browne, W. J. Baker, James Cremer, H. W. Clifford, O. H. Kendall, J. Mahoney, and W. V. Ranger.

It was a question of some moment to decide whether, for obtaining the photographic records, they should follow the plan adopted by the French and German expeditions of last year, and take the photograph in the principal focus of the object-glass, thus securing great intensity of light in a small image, or follow the method employed by Dr. De la Rue in 1860, when he used an ordinary Huygenian eye-piece so placed as to produce an enlarged image of the first image from the object-glass. It was found by experiment that with a clear sun it was necessary to reduce the aperture of the telescope (which was 4 inches, and 50 inches focus) to $1\frac{1}{2}$ inch, and to use a diaphragm slide of $\frac{1}{40}$th inch aperture, in order to get a proper exposure when the solar image was enlarged from ·6 inch (its diameter at the principal focus of the objective) to $2\frac{1}{2}$ inches on the ground glass. The same size of aperture was adopted for the larger instruments during the partial phases, the entire aperture, in all cases, of course being used during totality.

The work of designing and constructing these lenses, and also the different attachments to the cameras for securing exposures of various degrees of rapidity, from a very small fraction of a second to any desired length, was placed in the hands of Mr. Joseph Zentmayer, whose extended scientific attainments, combined with unrivalled skill in the construction of optical instruments, peculiarly fitted him for such a task.

As the operation of the eye-piece, when employed to produce an image on the screen or ground glass of a camera, is essentially different from that which it performs in its usual office, it was judged best by Mr. Zentmayer to make some alterations in its form. Thus, in the first place, since in the present case the "eye-lens" of the eye-piece undoubtedly makes a secondary image of the primary image formed within the eye-piece by the combined action of the objective and the field-lens of the eye-piece, it is clearly desirable to make this lens of a longer focus than usual, so that its errors may be of less account. It was also essential to give the new eye-piece a wide angle, so as to secure a sufficient field not only for the solar disc, but also for the corona.

While therefore the ratio of focal lengths in the two lenses of the ordinary eye-piece is usually 1:3, it was in this case as 1:2. While the distance between the lenses is usually the sum of their focal lengths divided by 2, it was here made equal to the sum of the focal lengths divided by 2, plus ·24 inch. This was to give space for the introduction of the reticule of spider lines, which would otherwise have been brought too near the field-lens, and also

to keep this lens beyond the conjugate focus of the eye-lens, as otherwise particles of dust on the former would have been too faithfully portrayed by the latter.

The elements actually adopted were as follows:—

	Ft.	In.
Focal length of objective	8	6
Radius of field-lens	0	1·375
„ eye-lens	0	0·687
Focus of field-lens	0	2·6
Diameter of field-lens (= R)	0	1·375
Focus of eye-lens	0	1·3
Diameter of eye-lens (= R)	0	0·687
Distance between lenses, 1·95 + 0·25	0	2·2
Equivalent	0	1·75
Distance of reticule from eye-lens for 5-in. distance of ground glass	0	1·62

When the instruments were boxed and packed, it was found that, with the various photographic appliances, they made no less than five furniture-car loads of material.

In arranging the division of the party into three sections, with the three telescopes, so that they might be distributed along the line of totality, and thus diminish the chance of universal extinction by local clouds, Professor Morton was chiefly guided by the desire of securing in each section such a diversity of special ability as might make each self-dependent and complete; also, to leave nothing undone to secure content and harmony of feeling. He assigned to himself the University telescope, which being of smaller size and without clockwork movement, could not be expected to do as good work as the others: though should *they* by chance be overclouded, *its* result would be invaluable.

The High School telescope, 6-inch aperture, 9 feet focal length, was under the charge of Professor A. M. Mayer, Ph.D., and Mr. O. H. Kendall. It was stationed at Burlington, 40° 48′ 17″ N., 0h. 56m. 13s. West of Washington. By measurements of the photographs taken by this party, Professor Mayer has shown a change of shape in one of the larger spots during the eclipse, amounting to a motion of 2000 miles, in its edges.

The Gettysburg telescope, 6-inch aperture, 8½ feet focal length, was in charge of Professor C. F. Himes, Mr. J. Zentmayer, and Mr. E. Moelling. This was stationed at Ottumwa, about 75 miles nearly west of Burlington.

With the University telescopes were Mr. E. L. Wilson and Professor Morton. This section was placed at Mount Pleasant, between the other stations.

It is almost needless to say that all officials connected with the railways acted with the greatest liberality in transporting the apparatus and observers to the selected sites.

The various parties having reached their destinations, arrangements were at once made to get the instruments into position. In

the case of the Burlington party, all went smoothly, and the dark weather alone prevented final adjustment until the night of the 6th, or morning of the 7th, when this was secured by Professor Mayer, who sat up all night for the purpose.

With the Ottumwa instrument it was, however, found that the clockwork had become seriously deranged in carriage, so that Mr. Zentmayer was obliged to take it entirely apart and refit it. The final adjustment was only given to this instrument during the morning of the 7th by Mr. Zentmayer, who had watched all night, vainly, for a star.

The telescope at Mount Pleasant having no clockwork, and being otherwise unfit for any fine adjustment, required no arrangement except what could be given during the morning of the 7th.

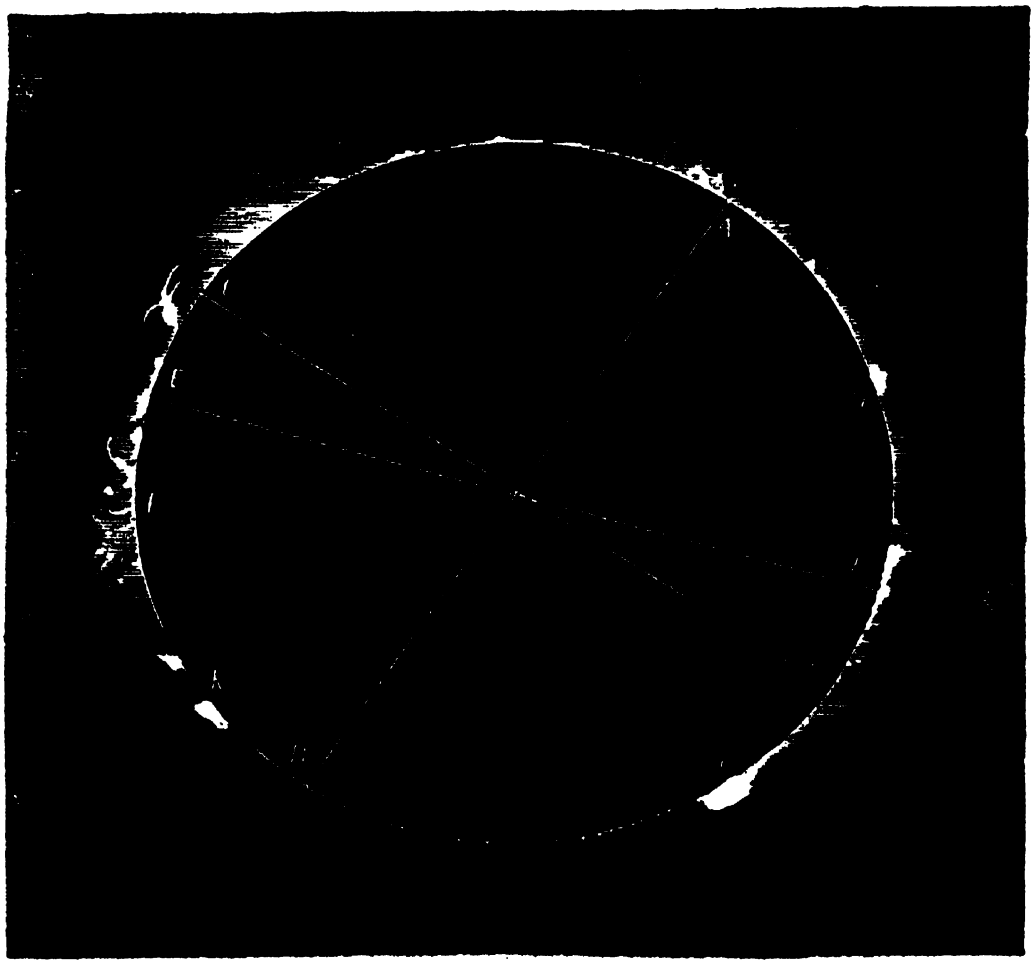
The weather on the eventful day of the eclipse was at all stations perfect, thus rendering needless the policy of distribution, and no less than 116 negatives were taken, including 13 during totality, showing a large number of prominences, some massive and others delicate as well as radiant brushes of a softer light, such as have been before seen, but never as yet photographed. By another of the sections of this large party, beside similar pictures to the above, one was obtained showing the curious phenomena known as Baily's beads, being simply the last glimpse of the sun's edge cut by the peaks of lunar mountains into irregular spots. The time of exposure determined by Professor Mayer for the partial-phase pictures was the $\frac{1}{500}$th of a second. Those taken during totality were exposed from five to sixteen seconds.

The general character of the prominences will be seen by the coloured illustration, which has been excellently copied from the original photographs and micrometric measurements forwarded to us by Professor Morton. The dotted circle inside the circumference of the moon, shows the relative diameter and position of the sun at the middle of the total eclipse. The accompanying woodcut may be regarded as a key to the coloured picture, and will serve to facilitate the following description of the phenomena:—

The line A B represents the direction of a parallel of declination. C D a declination circle. F E is the moon's path from first contact at F. The prominences are here all shown at once; although, of course, those on the sun's eastern limb alone were seen at first, those on the west side only at the end of the totality. Proceeding from the north to the east, we first meet with a small prominence having the position angle of about 56° 30′; it is of the shape of a rice grain, with its base but slightly below the circumference of the moon. In breadth it is 2° 50′, and in height 22″; as 1′ on the circumference of the sun equals 124 miles, and 1″ of arc of the sun's distance on August 7th subtends 449 miles, it follows that its actual dimensions are 21,000 miles long and 9900 miles high.

The next protuberance lies imbedded in the moon's border, and has in form the appearance of a short, deeply-articulated worm; its mean position is 69° 17′; its length 46,700 miles, and its greatest height 9900; between that protuberance and the point c on the woodcut, are two flames in the midst of the glow previously described. Midway the diffused light rises to an elevation of 60,500 miles. We now come to a curiously-formed protuberance. Some have compared it to an ear of corn, but in the photographs it appears like an eagle with outspread wings resting on the trunk of a tree which leans towards the north. On one plate where the tree-stump is cut off by the advancing moon, the resemblance to an eagle on the wing is perfect. The form of this object indicates instability,

FIG. 1.



and impresses one with the idea that it is a great travelling whirl of flame, the direction of whose rotation—as indicated by the position of the wings and the projection of one on the other—is retrograde, or in the same direction as the motion of the hands of a watch. Dr. Mayer, chief of the Burlington Section of the Philadelphia Photographic Expedition, has examined, with care, the successive photographs of it, and he says that although at first he thought that the last impression differed from those preceding in that the wings had become longer and more in a line with each other, yet on subsequent examination he could not really decide that a perceptible motion had taken place during the time of totality. The height of this object is 36,700 miles, and the spread of the

wings 70,800 miles. The next protuberance extends to between E and I on the woodcut; it is of very irregular outline, and shows portions of its substance detached from the general mass and floating freely above it. The most elevated and bright of these detached flames floats at a height of at least 20,000 miles above the surface of the sun. Beyond I a white nebulous cloud rises to the elevation of 60,500 miles. Next follow two protuberances at K.

We now pass to the western limb of the sun, and meet with the remarkably large and massive protuberance at G on the woodcut. It is shaped like a bird's head, with the beak and under-side of the head resting on the limb of the moon. On a photograph taken at Ottumwa, Iowa, just before the sun came out, this protuberance had the exact appearance of an albatross head with the beak open, holding a rounded mass between the extremity of the jaws. The protuberance at F bears the most striking resemblance to a caterpillar. It extends through an angle of 11°, or 81,800 miles; its maximum elevation, which is at the head of the caterpillar, is 23,000 miles. Out of the head issued two horns; the one nearest the front being the higher of the two, and terminated with a knob or ball from which curves a broken line of light to the border of the moon. The next prominence at H has the shape of a grain of rice slightly constricted in the middle. Between H and A is another protuberance.

Professor Young, who examined these prominences during the totality, has continued his spectroscopic notes of the prominences since the eclipse, and on September the 13th he obtained a view from which the accompanying woodcut is taken. He

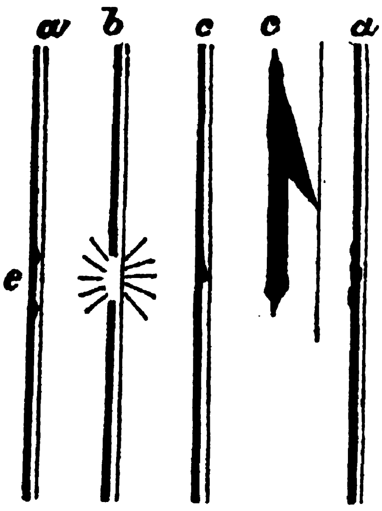
FIG. 2.

describes it as a long, straggling range of protuberances—the sketch giving a very fair idea of the number, form, and arrangement of the immense cloudy mass. The points *a* and *b* were very bright.

On September 18th he noticed a remarkable phenomenon, which, although not bearing directly on the eclipse phenomena, is sufficiently rare to make it deserve recording in these pages. Whilst examining the spectrum of a large group of spots near the sun's western limb, his attention was drawn to a peculiar knobbiness of the F line (on the sun's disc, not at the edge), represented by the following cut *a*, at the point *e*. In a very few moments a brilliant spot replaced the knobs; not merely interrupting and

reversing the dark line, but blazing like a star near the horizon, only with blue instead of red light. It remained for about two minutes, disappearing, unfortunately, whilst the observer was examining the sun's image upon the graduated screen of the slit, in order to fix its position. It is not known, therefore, whether it disappeared instantaneously or gradually. *b* gives an idea of this appearance. On returning to the eye-piece, Professor Young saw what is represented at *c*. On the upper (more refrangible) edge of F there seemed to hang a little black moat, making a barb, whose point reached nearly to the faint iron line just above F. As given on Angström's atlas, the wave-length of F is 486·07, while that of the iron line referred to is 485·92 (the units being millionths of a millimètre). This shows an absolute change of 0·15 in the wave-length, or a fraction of its whole amount, represented by the decimal ·00030, and would indicate an advancing velocity of about 55·5 miles per second in the mass of hydrogen whose absorption produced this barbed displacement. The barb continued visible for about five minutes, gradually resolving itself into three small lumps, one on the upper and two on the lower line, Fig. 1, *d*. In about ten minutes more the F line resumed its usual appearance.

FIG. 3.



Whilst on the subject of the solar prominences it may not be out of place to refer to some observations by Professor F. Zöllner, who has succeeded in observing them without an eclipse with great sharpness and clearness. From the nature of the method the same protuberance was simultaneously observed in three different colours corresponding to the three homogeneous lines of its spectrum. There is, however, a material difference between the red and blue image on the one hand, and the yellow on the other. The latter is very intense only in close proximity to the edge of the sun's disc, and in this respect corresponds to the other images; while the more delicate details disappear at a greater distance. This difference does not seem to be caused by the greater brightness of the spectrum in that region, but appears to depend on one of the two following hypotheses for an explanation:—either that the rays which give rise to the yellow image emanate from a gas having a greater specific gravity than hydrogen, and therefore existing at a lower level, or that the greater intensities of temperature and pressure nearer the surface of the sun cause hydrogen to emit these rays.

Professor Zöllner's paper, which will appear in the next number of the journal of the Franklin Institute (for early proofs of which the writer has to thank Professor Morton, the editor), is illustrated

with beautifully coloured drawings showing the rapid changes which sometimes occur in the forms of these prominences even in the course of a few hours. Observing one of the most remarkable formations, the Professor says, "I hardly believed my eyes when I noticed in it the tongue-like motion of a flame. This motion was slower, however, compared with the size of the flame than that of high towering flames at great conflagrations. The time required by such a wave in passing from the base to the apex was about two or three seconds."

In comparing the general impression of the protuberances with terrestrial phenomena, the author states that the great majority remind him of the different forms of our clouds and fog. The cumulus type is completely developed in the cases here referred to. Other formations remind us of masses of clouds and fogs floating closely over lowlands and seas, whose upper parts are driven and torn by currents of air, and which present the well-known ever-varying forms when viewed from the tops of high mountains.

Professor Zöllner hopes, by using larger prisms and a circular slit in the spectroscope, to be enabled to observe simultaneously all the protuberances on the edge of the sun, in the different parts of the spectrum, just as in a total solar eclipse of long duration.

Returning to the August eclipse, one of the most beautiful observations was on the first contact by means of the spectroscope. Professor Young has been giving much attention to this subject, and had fitted up a very efficient instrument for the purpose. The instrument consisted of a spectroscope with five prisms of 45° each, having faces 2¼ by 3¼ inches; the collimator and telescope had apertures of 2¼ inches, with a focal length of 17. These were connected with a comet-seeker of 4 inches aperture and 30 inches focus, used with an eye-piece, and giving an image of the sun 2½ inches in diameter on the slit of the spectroscope. A graduated screen at the slit determined positions of points on the sun's limb, and a wire micrometer measured the positions of spectrum lines. The whole was mounted equatorially with slow-motion screws. During the eclipse he was stationed at Burlington, Iowa, and shortly before the first contact was due, he found that there was a solar prominence located at the spot where first contact must occur (see F in cut on page 33). He therefore fixed his spectroscope with the slit radial to the solar edge at the point, so getting a prominent spectrum whose width was determined by the height of the prominence. Closely watching this, he presently found that it began to narrow steadily, and at the instant that it became a mere line and disappeared he recorded first contact. The moon's approach was perceived full 30″ before its actual appulse; the observation was perfectly easy, and the time determined is certainly to be relied on within half a second, and probably much less. The presence of a prominence at the point of contact is not

essential to the success of the method, as there is everywhere on the sun's limb sufficient depth of chromosphere to answer the purpose. From the first photograph showing contact made by the Philadelphia party at the same place, Professor A. M. Mayer, who had charge of that division, calculated the time of actual first contact, and found that it came within two-tenths of a second of the record made by Professor Young.

Professor Young proposes to apply the spectroscope in this manner to observations both of the external and internal contacts at the next transit of Venus.

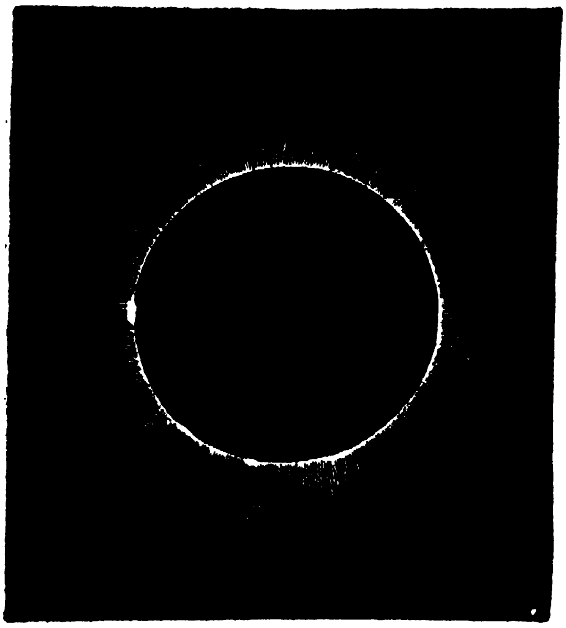
The partial-phase pictures show the various sun-spots visible at the time (about six in number) with admirable definition, the larger ones being surrounded by a marked fringe of faculæ. They all show a beautiful gradation of shade from the border of the sun inwards. This shading of the source of light is due to the absorption of the peripheral rays which necessarily pass through a greater thickness of the dense solar atmosphere than those which emanate from the central portion of the disc; on a more searching examination of the relative intensities of light of different portions of the solar disc, there may be observed on all of these photographs, close to the limb of the advancing or retreating moon, a bright glow like that of early dawn, which extends from the moon to a distance of about 15″. Unless this glow can be accounted for in node and in measure by diffraction, it would appear as if it were due to a lunar atmosphere, although Dr. Mayer, in suggesting this explanation, confesses that he cannot understand how an atmosphere capable of producing such marked effects when projected against the intensely lighted disc of the sun, should have no appreciable refractive effect on small stars when occulted by the moon. We should be more inclined to account for this glow as being the effect of specular reflexion from the surface of the moon grazed by the sun's rays.

A party under Professor Pierce devoted themselves exclusively to the recording of that strange phenomenon, the corona. To secure any impression from this object, which, notwithstanding its apparent brightness, is remarkably deficient in photographic power, it was necessary to make a very small image and to give a very long exposure.

The telescope was therefore arranged to produce an image in its principal focus simply, and during the totality an exposure of forty seconds was given. By this means a picture was obtained of which the cut on the next page is a very careful copy. From the long exposure, the motion of the moon, and probably also of the light in the corona, there is little sharpness of definition, and the prominences only appear as bright spots. The general shape of the corona is, however, very well given, and the curious appearance of curvature, in some parts, is very manifest. Professor Himes, who

was at Ottumwa, describes the corona as approaching much more nearly in regularity the four-rayed form generally given, and which had always seemed idealized or conventional. The S.W. ray was, however, unequally subdivided with the smaller part towards the north. The whole seemed of a fibrous, slightly curled or twisted character, somewhat like a cirrus cloud, and of silvery whiteness. The prominences, especially the large one a little to the left of south, seemed at the first instant of a dazzling white, but after his attention had been diverted for a few moments, it appeared of a brilliant decided rose colour bordering on crimson, and remained of this colour to the close. To Mr. Zentmayer, who was engaged at the camera and had used neither telescope nor screen, it appeared white, with a slightly roseate hue. To Mr. Moelling, under similar conditions, it appeared white throughout. Messrs. Brown and Baker, who had a short glimpse of it from the door of the dark room, rather incline to the opinion that it was white. Professor Pickering, who was at Mount Pleasant, Iowa, describes the corona as an irregular four-pointed star with, of course, a black centre. Two of the rays were nearly vertical and two horizontal, the left-hand one pointing somewhat downward, while between it and the lower ray was a fifth smaller point. The colour was pure white, very different from the full moon, but resembling a cumulus cloud. Its texture resembled the ragged edge of a thundercloud, or the crest of a wave torn by the wind. The striæ were not radial but spiral, as if the sun had been turned in such a way that the upper edge moved towards the east.

FIG. 4.



During the totality Professor Young gave special attention to observation of the corona with the spectroscope. He found that, in place of a subdued solar spectrum, which would have been anticipated from the reports of former observations, it yielded a spectrum of bright lines. These are represented in the coloured illustration, and below the spectrum of the corona is given a copy of the spectrum of an aurora borealis as observed by Professor Winlock on the evening of April 15th. From the close accordance between the coronal lines and three of the auroral lines, Professor Young considers it almost certain that the corona is simply an electric discharge, no doubt varying with great rapidity, as we see in the case of the aurora; in fact, that the solar corona is a permanent aurora. It is, however, right to state that in an article by

Mr. J. N. Lockyer in 'Nature,' for November 4th, he throws some doubt on this conclusion, and hesitates to regard the question as settled, were the new hypothesis less startling than it is.

The most complete series of spectroscopic observations were those taken of the prominences. During totality nine bright lines were observed by Professor Young in the spectrum of one of the protuberances, *viz.* C dazzling in brilliancy; 1017·5 (near D, the numbers refer to Kirchhoff's scale) very bright, but not equal to C; 1250 ± 20, very faint, position only estimated; 1350 ± 20, like preceding; 1474 (a little below E), conspicuous, but not more than half as bright as 1017·5; F next to C in brightness; 2602 ± 2, a little fainter than 1474, position determined by micrometrical reference to the next; 2796, a little below G; the well-known H γ line in brightness between 1017·5 and 1474; and finally *h*, or H δ, somewhat brighter than 1474. *b* it is supposed was not seen; on account of a mistake in carrying that portion of the spectrum through the field, there was no prominence on the slit. The lines marked H in the coloured illustration are hydrogen lines.

The opportunity which was afforded by the total obscuration of the sun's light was taken advantage of to search for planetary bodies between Mercury and the sun, but without success, although Mercury, Venus, Mars, Saturn, Regulus, and Arcturus were plainly visible. The horizon all around was lighted up by a sort of dim twilight for four or five degrees in breadth, and above this rim of light hung a leaden canopy, increasing in depth towards the zenith.

At the Ottumwa station a curious appearance was noticed by Mr. Zentmayer. During the time that the pictures of the partial phase were being taken at long intervals, the ground-glass plate was put in the camera to note any irregularities in the clock movement, should they occur. About twenty-five minutes before the totality, Mr. Zentmayer observed some bright objects on the ground-glass, crossing from one cusp to the other of the solar crescent. Each object occupied about two seconds in passing, and they all moved in right lines, nearly parallel, and in the same direction. These points were well defined, and conveyed to the mind of Mr. Zentmayer, who is accustomed to the use of the camera for photographic purposes, the strong impression of being images of objects, and not points of light merely. It is, moreover, certain that the objects, whatever they might be, must (in order to have produced such sharply-defined images on the ground-glass) have been several miles distant from the telescope, as even a point of light at a less distance would have produced an enlarged image, with a hazy border.

The most complete account of the photographic operations is recorded in the report to Professor Morton by Dr. Mayer, who was the chief of the Burlington party. They arrived at their destination

on August 4th, and up to the morning of the 7th they were occupied in putting together the base and frame of the telescope, mounting the bed-plate, the polar and declination axis and circles, the cradle holding the telescope, fitting-in the tube and optical part, adjusting the verniers and bringing the instrument into altitude and azimuth adjustment. The whole of Friday, August 6th, there was a driving rain, an east wind, and a dull murky atmosphere, foreboding the worst results on the morrow—after having spent previous weeks in preparation, and having travelled over a thousand miles, in the hope of carrying back with them permanent photographic records of the long-thought-of eclipse.

As they retired to rest there appeared signs of the clouds breaking. They had barely fallen asleep when the clerk, according to previous arrangement, woke them with the agreeable news that there were plenty of stars. They were soon dressed, and were charmed by the sight of a cloudless sky; and Professor Coffin, Drs. Gould and Mayer were up all night putting their own special instruments in adjustment. When all was finished, the sun was rising, and the air as pure and serene as one could wish. On Saturday morning the chronograph was mounted, and electric wires were led to the camera, to Professor Young's spectroscope, and to the station of Dr. Gould outside the building. The two threads of the reticule of the camera were placed one parallel and the other at right angles to the celestial equator, and experiments were now begun by Mr. Willard to ascertain the chemical focus. This was obtained after the tube had been following the sun for an hour or more, and after the focus was fixed the clockwork was kept going, so that no change in focus should supervene from a change in temperature in the lenses and tube. The clockwork adjustment had been regulated with such accuracy that it drove the telescope so that a star would remain closely bisected for twenty minutes. By 3 P.M. all was in readiness, and each one at his allotted post of duty, ready for work.

The image of the sun was 2·04 inches in diameter, and was taken on a $4\frac{1}{4} \times 5\frac{1}{2}$ inch plate. Mr. Zentmayer had so constructed the camera eye-piece, that the image of a reticule of two spider-threads at right angles to each other was formed on the plate with the image of the sun, and these threads were so mounted that they could be adjusted respectively parallel and at right angles to the celestial equator, and thus fix on the photographs the positions of the sun and moon, and give the position angles of points on the surface and periphery of the sun.

The tube carrying the camera lenses screwed into a plate in which, immediately in front of the anterior lens, was a guide, in which a thin plate having a horizontal slot of ·0224 inch in width was caused to descend by the action of a spring. This was used

for the partial phases. During totality the full aperture of the object-glass was employed, and a slide plate was used; having a circular opening which allowed the full beam to pass. This plate had two falls instead of one. On setting the plate free by the top trigger it fell, and the collodion plate was exposed to the entire beam; after the desired exposure a lower trigger was relieved, and the plate made a second fall, and the lens being covered by the top of the plate, the exposure ceased. These triggers were connected with a Morse register having a paper fillet running through it; at every second the clock for an instant opened the electric circuit, and there was a very short break made in the line marked by the pen on the fillet; thus the seconds of *time* were stepped off in *space* on the paper ribbon. The triggers were so connected with this chronograph that an additional break was made during the time the photographic plate was being exposed. By measuring this break on the paper ribbon and comparing its length with the length of the second in which it occurs, the exact fraction of the second during which the plate was exposed will be given.

Dr. Mayer arranged for his own duty to keep the telescope in adjustment, and to manipulate the apparatus of exposure and chronographic registration, while Mr. Willard placed the plate in the camera and gave the several times of exposure he desired during totality. Mr. Phillips coated the plates and handed them to Mr. Montford, who carried them to Mr. Willard, and thence, after exposure, to Mr. Mahoney, who developed them, assisted by Mr. Leisenring.

The wall of the dark room adjoining where the telescope stood was fitted with two dark valves, or dumb waiters, by which the plate-holders could be passed in and out without the admission of light or the necessity of any of the operators moving from their places. Seven negative baths were used, standing in a trough of water to keep them cool, four plate-holders, and a large wooden trough with grooved sides, similar to a negative-rack; this was filled with a weak solution of hyposulphite of soda. In the dark room the first operator's duty was to coat plates and put them into the baths; the second took them out, put them into the plate-holders, and passed them out of the room by means of one of the dumb waiters. After exposure, the holders were returned to the dark room by the second dumb waiter, when the third operator took the plate from the holder, developed, washed, and then dropped it into one of the grooves in the large fixing trough. There the plates remained slowly fixing till after the eclipse was over, when they were taken out in the same order in which they were put in, washed, and numbered with a diamond.

At the telescope Mr. Rock was detailed to attend to the very important duty of calling out the seconds of the chronograph-fillet;

Mr. Kendall called out the minutes at each 60-seconds call of Mr. Rock, and wrote it on the fillet. He also had charge of the chronograph, and started it when Dr. Mayer called "clock," while, at the same signal, Mr. Rock began the registration of seconds.

Dr. Mayer had laid out the following programme of work:—First to take in rapid succession, beginning 10 seconds before the computed time of first contact, a series of five photographs. Secondly, one just before second contact, one just after second contact, as many as possible during totality, one just before the end of totality, and another just after the sun reappeared. Thirdly, to take again a series in rapid succession about the end of the eclipse. Fourthly, during partial phase, to take a picture every four or five minutes.

When the chronometer marked 12 h. 48 m., Mr. Rock began to count and register the times on the fillet. Every one was at his post, the lanterns lighted, and nothing could be heard but the count and tap of the chronograph. At 12 h. 49 m. 45 s. the first photograph was taken, and following at intervals of from 10 to 12 seconds five perfect pictures were secured. The contact is first visible on the third. Photographs were now leisurely taken at intervals of about four minutes, until twelve plates in all were taken.

About five minutes before totality, Mr. Willard removed the diaphragm of two inches aperture, which was used during partial phase, and exposed the full aperture of the object-glass, whilst Dr. Mayer changed the slide with ·0224-inch slot for the one which admitted the whole beam at once on the plate in the camera.

The order was given to prepare the plates. The first plate was taken at 13 h. 51 m. 39·15 s., or 7 seconds before the time of second contact as observed by Professor Coffin. The slide was soon reset for another exposure, and as Mr. Willard desired the first plate of totality to be exposed five seconds, Dr. Mayer kept on counting zero, zero, zero, with the taps of the chronograph, until striking the upper trigger at zero, he counted one, two, three, four, five, when the lower trigger was struck and the plate removed.

Counting the first plate, taken seven seconds before second contact, six photographs were taken in 2 m. 3 s. After the sixth was removed there still remained 50 s. of total phase. There was a delay in the plate. The observer grew impatient; he called plate! plate!! but, alas, it was found impossible to manipulate more than six plates in two minutes and three seconds. The store had been used up too rapidly, and so they did not succeed in getting an impression just before the sun came forth. The next plate was taken 29·2 seconds after third contact, and is a valuable photograph of a thin crescent, with the cusps sharply cut.

Dr. Mayer describes the appearances during totality in the following words:—"About 15 minutes before totality it became so cool that I was obliged to put on my coat. A minute or two before

totality, the sky grew ashen, or rather leaden in hue, and as, with face turned towards the sun, I kept the count from the chronometer for the first exposure, Venus and Mercury came out shining beautifully on a ground of bluish grey. I thought I saw a flashing, twirling motion in the corona, or in the last rays of the sun; but of this I will not be positive, for my attention was not, at the time, specially directed to minute observation. Moths and insects in profusion passed between me and the sun, while a flock of birds with troubled irregular flight seemed seeking cover from the unnatural gloom which surrounded them. A low moaning wind now sprang up, and the whole atmosphere seemed filled with a lead-coloured vapour, and I experienced an indescribable feeling of oppression when I tapped the trigger, and, from that instant until the sun appeared, I had nothing but an *instrumental* consciousness, for I was nothing but part of the telescope, and all my being was in the work which I had to perform. I reset the slide, made circuit, exposed, and so on over again, until the six photographs were taken, when I had the mortification to find 50 seconds of totality, and that no plate could possibly be obtained; we were *too* quick."

Photographs were now taken leisurely at intervals of about four minutes until 14 h. 47 m. 48·4 s., when the first of the series for the end of the eclipse was secured; this was followed by four others at intervals of about a quarter of a minute. The work was finished in a few seconds, the eclipse of August 7th, 1869, was of the past, but its history had been faithfully recorded in forty-one perfect photographs.

IV. INSTRUCTION IN SCIENCE FOR WOMEN.

It would seem hardly necessary, in this day of awakening common sense, to put the questions, Is it necessary to impart scientific instruction to the female sex? and what kind of information should be conveyed to women?

As to the first inquiry, there are, no doubt, still a great many old women of both sexes who consider that if a girl be taught to read, write, and know sufficient of arithmetic to enable her to detect errors in her butcher's or washerwoman's book, any further intellectual instruction is superfluous, and unfits her for household duties. But it being once admitted that such a proposition could only emanate from old womanhood, in the disrespectful sense of the term, and that scientific instruction would be of the greatest benefit to those whom we shall still delight to call the fair sex—not the less fair because more intellectual—we need have no difficulty in determining what should be taught to them, and in what manner the instruction should be imparted.

As a mere education of the intellect, there is no reason for making any difference between the method of conveying scientific information to male and female students. It may be said that some branches of physiology are not fit subjects for young girls—neither are they for young boys;—and with more propriety it may be urged that the refinement of woman's nature would be shocked or deteriorated by the receipt of certain information from men, even when the pupils have arrived at the age of maturity. But this is only another argument in favour of every effort being made, without loss of time, to train women to be the teachers of their own sex in the mysteries of human anatomy and physiology.

To deny the necessity of imparting this particular kind of instruction at all is simply absurd; for whilst women may make good wives and mothers, without possessing any knowledge of Botany, Electricity, Astronomy, or Chemistry, they cannot possibly be fitted to fill their accustomed sphere without a fair amount of information concerning the laws which govern their own corporeal frame in health and disease, and somewhat at least of the constitution of the other sex.

That assertion will no doubt be met by the stock argument, "How have our fathers and mothers and our ancestors managed without such knowledge?" or, "What are doctors for?" They have managed to lose one, or two, or three children in succession from the effects of disease; or perhaps it would be more correct to say, from ignorance of the meaning of directions left by their medical adviser, when by a little intelligent care all would have survived. It is not the doctor who saves the patient's life; it is he who directs how it is to be saved; and however able the physician may be, the fate of the patient, in five cases out of six, depends mainly upon the intelligent construction and fulfilment of his wishes by the nurse. Of what use, at a critical period of disease, is any amount of information concerning the latest novel or opera? Will the most artistic display of chignon, or the widest acquaintance with the mysteries of fashion, avail to protract the hours of a beloved husband, or the moments of a child's life, whilst it sinks under an exhausting disease?

It would be a waste of time to discuss here the best system of imparting general scientific instruction to women, as distinguished from men; but it may be interesting to dwell for a few moments upon the method which is being adopted at South Kensington—not because it appears to be efficient in the case of women only, but because, being advantageous in their case, it would be beneficial wherever minds untutored in science are to be appealed to, and the effort made to convey scientific information. And having briefly considered that phase of the subject, we will cursorily refer to the special instruction in those branches of science which would

seem the best adapted to favour, materially and mentally, the progress of females as working women.

The series of lectures at South Kensington, which, it should be premised, is by no means the initiation of the movement, consists of three courses—one by Professor Huxley, on what he calls Physiography; a second by Professor Guthrie, of Jermyn Street, on Elementary Physics and Chemistry; and a third by Professor Oliver, of Kew, on Biology. The last named is, however, chiefly, if not entirely, confined to Botany and Vegetable Physiology. Of Professor Huxley's lectures we will speak first, and to illustrate his method of imparting tuition, we will endeavour to describe his introductory lecture.

"Physiography" is explained to mean "a description and rudimentary analysis of those obvious natural facts and events which are commonly treated of under the head of elementary physical geography;" and in his introductory lecture Professor Huxley described the changes which are taking place in a river basin, as illustrated by the ebb and flow of the tide in the Thames, the supply which it receives from its tributaries, from the condensation of watery vapour in the atmosphere, and from other sources.

The information which he desires to convey seems of the most commonplace character, consisting of an account of the form of the Thames Basin; the appearance of the river as seen from a balloon; the relative extent of the fresh and salt water currents; the bulk of fresh water which flows down to the sea, and never returns; and so forth. But it is more than probable that not six of the ladies present (for they were all ladies in the conventional sense of the term who constituted his audience) possessed even a superficial acquaintance with the phenomena in question, and perhaps not one would have been able to answer correctly the questions which might have been put from his programme. Nor is this anything to their discredit. How many of our readers are there who could tell us what number of cubic feet "more water runs down than runs up beneath London Bridge every day?" or where "Thames Head is?" or "How far it is from London Bridge, and how high it is above the Thames at that bridge?"

The lecturer managed, however, not only to instil this information into his hearers' minds, with the aid of a chart and black-board; but with his bottle of cold water, which served at the same time to refresh his body and illustrate his subject, he explained with great clearness the laws and phenomena of radiation, heat, congelation, &c., and some of the leading principles of meteorology. His address may be said to have been an ideal picture of the cycle of changes which are constantly going on between earth, sea, and air, in so far as the transfer of water is concerned. In his subsequent lectures he described (or intended to describe—for this article was

written shortly after his opening lecture) similar phases in the circulation of solid matter (earth), and the transformations of living matter (plants and animals).

Turning for a moment to the lectures of Prefessor Guthrie, on Physics and Chemistry, it may be asked of what use instruction in chemistry can be without laboratory practice; and although it is probable that the ladies will see none of that at South Kensington, and indeed that only the most rudimentary instruction in chemistry can be imparted in a course such as Professor Guthrie will give; yet when we look at what is being done elsewhere, we shall find not only a supply, but an active demand for laboratory instruction.

Mr. Mylne, the Honorary Secretary of the Ladies' Educational Association, which carries on its operations in connection with University College, has sent us a programme of the scientific lectures in course of delivery at the College in Gower Street, and he informs us that Professor Williamson not only gives instruction in theoretical chemistry, which we find from the prospectus to embrace the organic as well as the inorganic section, but that he has instituted laboratory practice, several ladies having expressed a wish for this mode of instruction. In connection with this series of lectures it may be further added that Professor G. C. Foster is delivering a course on Dynamics and Heat; and Professor Hirst one on Geometry. There are lectures on the living and dead languages and literature, but with those we have no concern here.

Professor Oliver, at South Kensington, proposes to illustrate the laws of biology, as we have already stated, chiefly by a reference to the realm of plants; indeed, so far as we can ascertain his views at the time of writing this notice, he intends to follow the admirable plan of making his lectures as much as possible a series of demonstrations with living plants.

Many gentlemen, either amateurs or professional men, are devoting their time to further this kind of instruction to ladies. At South Kensington, the Hon. and Rev. Francis Byng, and Mr. Owen, of the Museum, are taking an active part in the movement.

Professor Sedgwick, of Trinity College, Cambridge, and his brother, of Merton, have delivered courses of lectures, we believe, at Preston, Manchester, &c.

Most of the Professors of Natural Science at Oxford have given lectures to ladies at one time or another, Mr. Harcourt having delivered a course to "women and children;" and Dr. Child a series on Physiology last year at Clifton.

Mr. James Stuart, Fellow of Trinity College, Cambridge, is now delivering a course of lectures to ladies, in Liverpool, on Natural Philosophy, embracing the subjects of Light, Heat, Magnetism, and the most recent discoveries made by spectrum analysis. Papers are

written by the class, and certificates of the 1st, 2nd, and 3rd class are given at the end of the course. The class numbers 165 students. In Leeds and Bradford, Mr. T. Aldis, of Cambridge, is delivering courses of lectures to women on the History of Physical Science. These gentlemen are lecturing under the auspices of the North of England Council, of which we believe Mrs. Josephine E. Butler, of Liverpool, is the President. Scientific lectures are also being delivered in Dublin and Edinburgh; in the former city at the Alexandra College for the Education of Ladies, by Dr. Macalister; and in Edinburgh by Professor Fraser on Natural Philosophy; and by Professor Tait on Mathematics. In addition to these it may also be mentioned that at Sir Patrick Dun's Hospital in Dublin instruction is given to soldiers' wives to prepare them for the vocation of army nurses. They are taught the laws of health, and the conditions of climate in relation thereto, of the principal stations of the British army; as well as the theory and practice of midwifery; and on passing a satisfactory examination they receive certificates of merit and pecuniary prizes. It is, of course, hardly necessary to state that at every Science School or Class in the United Kingdom connected with the Science and Art Department, women are not only admitted on an equality with men, but are treated with courtesy and consideration; but whatever may be said concerning the educational association of the sexes, we have found from personal observation, that, for the present at least and chiefly so far as women are concerned, they prefer being taught apart.

Having given this imperfect outline of what is being done in the way of general instruction in science to women, let us now inquire for a moment how and what it would be desirable to teach them with a view to their advancement in particular trades or professions. In this matter we may obtain some useful hints from what is doing abroad and at home for the education of artisans. For example, in some of the German towns special books and classes exist for instructing workmen in the theory of their trade, and in Liverpool lectures are about to be commenced with the same object. One course, which may serve as a type of this class of instruction, is about to be given by Mr. Norman Tate, on Chemistry applied to the practical arts. The first lecture is general, being on the relations of chemistry to industrial pursuits; then there are to follow two which will interest engineers, as they relate to Air, Water, Heat, Fuel in its application to the production of Heat, and the practical working of fuel for steam in furnaces, &c. Two follow on the Metallurgy and the Chemistry of Metals. After these there are lectures on building materials, stones, slates, bricks, mortar, cements, &c., for builders; earthenware and glass, for glaziers; pens, ink, and paper, for printers, &c.; paints, varnishes, and colours, for painters and decorators; horns, bones, leather, feathers, &c., and

woods, for persons engaged as upholsterers and cabinet-makers—and one lecture on oil, fats, soap, &c.

Now, if we substitute the employments of women for those of men, and consider what branches of science are the most serviceable in those employments, we at once arrive at the solution of the problem. First, there are certain subjects on which all women should be tolerably well instructed, such as, for example, sanitary science; the broad principles to be borne in mind in coping with disease, or for the maintenance of health; and so much knowledge of anatomy as will enable a woman to bind a wound, or palliate the effects of an accident until medical aid arrives. Such knowledge is obviously indispensable to all women, whether married or single, and its diffusion would save many valuable lives in the lower ranks of society. But now we come to trades and handicrafts. Of course, each town has its special industries, and the professional men, or employers of female labour in Birmingham, Sheffield, Manchester, and other large towns need not be told whether classes in chemistry, or metallurgy, or physics, would the best subserve educational purposes amongst their workpeople. But what is more obvious than that a number of girls employed in working the electric telegraph would be the gainers by having a sound knowledge of electricity; or that young showwomen or saleswomen in any trade whatever might with advantage be taught certain branches of physical science? A girl who is constantly asked by customers whether she has goods of this or that colour or texture, would surely be the better for knowing something of the laws of colour, or the history of textile fabrics; and it would certainly do her no harm if she were acquainted with the chemical processes whereby the beautiful dyes and pigments with which she is familiar are obtained, sometimes from waste products.

What we suggest, then, is that the promoters of this excellent movement should not content themselves with imparting science instruction to young ladies, and such females as can afford to pay two guineas for a course or half-a-crown for a single lecture, and who can devote the forenoon to the acquisition of such knowledge. They should open evening classes, in which instruction should be given to women of the industrial classes (in which are included shopwomen), and to female teachers in national and other schools. To these the charge for admission should be nominal, whilst the character of the instruction to be imparted should completely accord with the trade or vocation of the recipients.

V. ON IDIOCY.

By P. MARTIN DUNCAN, M.B. Lond., F.R.S., &c.

WHAT became of the idiots in the days of antiquity? Were there any amongst the early races of mankind? How is it that they are hardly mentioned by classical authors, and not noticed at all in Holy Writ? These are questions upon which those who are aware of the multitudes of idiots in the most highly civilized modern communities may speculate freely, but not very satisfactorily. The term idiot is of course Aristotelian. The existence of peculiar members of the human family who were "solitary" was known to the founder of that philosophy, and he clearly recognized the absence of the *vie de relation* amongst those he so well and aptly termed "ἴδιος" in kind. Children and adults who could not be communicated with, and who could not place themselves *en rapport* with others, were considered to be "solitaries;" they were beyond the sympathies, and were heedless of the love of the human race, and they were incapable of expressing the desire for or of seeking companionship. Probably Grecian idiots were very much akin to those of modern date in their deficiencies and peculiarities. They stared open-eyed by the hour, or they waved their hands about, beslavered their bodies, and wearied the beholder with automatic movements. They were as heedless of the weather as of the voice of authority, and they had neither reverence for the priest nor admiration for the goddesses or their living representatives. Alone amongst the multitudes, thoughtless amongst the philosophers, unloving when embraced, caring for no one, having neither friends nor foes, the "solitaries" of old were not unsurrounded by a faint atmosphere of sanctity even amongst the Greeks. They were unlike all other children when young, and could not be associated with in mental communion when old. They had no greed of gold; food they did not live for; luxury they were careless about; and of ambition they had none. The Helot might look upon the heedless solitary with slight respect, and call him a fool like a practical Anglo-Saxon; but his philosophic master, with his yearnings after the abstract and unknown, and with his dim misgivings concerning his own origin and future state, evidently associated the condition of his fellow-mortal with a mysterious and personal relation to the gods. He gilded the gingerbread humanity with a halo of sanctity, but the slave doomed to work did nothing of the sort. The men who recognized something more than a fiction in the myth of Prometheus gazed into the fixed eyes of the "solitaries" and speculated upon the possibility of the existence of an inward life of thought behind those dull orbs, and of a close affinity with the hidden intelligence of Zeus. Was there an Elysium within and a Tartarus

clouding the without? Was there a curse which still could not extinguish the celestial fire? Bound with iron on the rock, torn by the everlasting bird, ever living, never dying. Thus with the type of organic life, was it thus in degree with the living example of a mindless body? There was no aberration evident to the thinkers of old in the "ἰδιος;" he was not chased by the Furies, but he was bound with invisible chains. Psyche was hidden, but the Satyr was free. The priesthood could but recognize some of the psychical conditions of the solitary in the exhausted and mentally collapsed state of the oracular virgins after prolonged religious excitement, and after the influence of the ritualistic therapeutics of the day had ceased to stimulate. These thoughts were probably common enough in a land where nature was luxuriant and where incessant toil was not requisite for existence. Farther to the east, where the struggle for life has never been great, there has been no hesitation in asserting that the idiot and the insane are under the especial care of the Deity; and amongst the followers of Mahomet the first of these has ever been looked upon with awe from the apparently willing self-exposure to the noonday sun, to the bitterest cold, and from the total disregard of consequences.

There is nothing in the cuneiform writing of the Babylonians nor in the hieroglyphs of the Egyptians to denote the existence of idiots during the time when those empires flourished; and it is very remarkable that there should not have been any notice of the idiotic state mentioned in the Book of Leviticus in the catalogue of those physical defects which were to prevent the priest from taking an active part in the ceremonial of the Tabernacle.

If misery, social degradation, and the free indulgence of the animal passions involve idiocy, there ought to have been plenty of it during the whole of the Roman Republic and Empire wherever the eagles rested. But there is much silence on the subject throughout the Latin authors. There were idiots in those days, and the practical Roman looked upon them as useless entities. They had no sanctity in his eyes, and hence their probable rarity. Doubtless the unfortunate children were neglected, and there is much reason for believing that they were "exposed." A congenital idiot soon begins to give trouble and to excite unusual attention; moreover, unless extra care is given to it, death is sure to ensue in early childhood. There are some very curious passages in the Latin classics that refer to the burial without cremation of very young children, and it is evident that although the laws against intramural sepulture were very stringent, there were instances where it took place surreptitiously. There is some reason for believing that many of the babies whose skeletons are now and then found close to Roman villas in this country and on the Continent had been buried there before teething had commenced, and that they

had died from a peculiar incapacity for receiving nourishment in the usual way. This defect is common enough in profound idiots. Under the most favourable circumstances the Roman infant had a sharp struggle for existence, and the amount of the mortality of the young may be estimated, if we leave the question of idiocy out, by the number of skeletons discovered in the "suggrundaria"—under the eaves and close to the walls of houses. At Chesterford * no less than fifteen skeletons of infants were found close to the walls of a Roman villa discovered in 1852. The bodies were associated with a corresponding number of small vessels of Roman manufacture. It would seem that their parents had done all in their power by providing them with nourishment to soothe them and stop the crying, which Virgil, in the narrative of the descent of Æneas to Hades, in the 6th book of the Æneid, mentions thus:—

> "Vagitus et ingens,
> Infantumque animæ flentes in limine primo."

The shades of the children were crying, and on the first threshold, that is just without the doors—an allusion no doubt to the place of their sepulture. The laws against intramural burial extended to the case of children who were subject to be buried in the cemeteries but not to be burned. Pliny tells us that children cut their teeth in the seventh month!!! and proceeds to inform us that it was not customary to burn their bodies before that time. Juvenal also describes the funeral of a child without fire—

> "Terra clauditur infans, et minor igne rogi."

Fulgentius says that baby bodies were not burned until they were forty days old. There is, then, some reason for believing that the interment laws were broken in the case of such children as were idiotic and still-born. These were buried quietly in the "suggrundaria."

Those idiots whom we call simpletons, and who are not really solitaries, but approach the lowest types of the perfect in mind, were doubtless common in those Roman families where there was wealth and freedom from the usual active competition with the world. Doubtless there was many a big Roman, solemn and staid-looking, who was studiously silent and dressed in the quietest toga, just as there are magnificent-looking men, but, oh, how simple, who now-a-days follow the wise precept of holding the tongue and wearing black. The range of mental deficiency, from the true solitary through those who are mimics and mischievous incapables, to the solemn and sometimes witty fool who just verges on the

* An admirable description of this discovery, from which I have quoted largely, is in the 'Trans. Essex Arch. Soc.,' 1858, by the late Lord Braybrooke.

most stupid of perfect mankind, was not noticed by the Roman alienist physicians.

There are no notices of idiots in the time of Arabian learning, when Europe was linked on to civilization by its clergy; and the affliction is never seen, so it is said, amongst the pure Arabs of the present day, who continue generation after generation to marry their uncles' daughters as a matter of course. This intermarriage occurs in many nations, living in what we call a very absurdly savage state, and yet idiots are either rare or absent amongst them.

The history of idiocy is then to be written in a very small space, yet the condition is one of the greatest curses of modern times.

There are at least 10,000 pauper idiots in England and Wales, and there are 1760 idiots confined in workhouses and lunatic asylums in Ireland, but how many there are out of doors is unknown. In France there are 2·5 idiots born in every 1000 births. There are no statistics that can decide how many idiots there are in private families in Great Britain, but every alienist physician knows their number is legion. They are kept out of the way, shut up, being looked upon as a disgrace to the family, for people do not discriminate between the causes that give idiots to the drunken and reprobate, and those that induce idiocy in the families of the purest in mind and who lead the gentlest of lives. There is no greater trial in a family than the presence of an idiot child, for it not only attracts too much maternal care, but it affords, as it grows, a bad example to the other children. Supposing that there are two idiots born for every thousand of healthy children, what a mass of hidden suffering there must be around us for which there is hardly any relief.

The percentage of idiots increased in Ireland as the general population diminished after the famine and during the subsequent emigration; it is very large in France, whose population is at a standstill; it is great in North America, where the population is most mixed; and it is greater in those English counties where there is an agricultural population, earning poor wages and looking to the Union as their haven of rest, than in the others. In Herefordshire there were, a year or two since, 111 idiots (pauper) in 106,796 inhabitants, or 1 in 962; in Wiltshire, 237 pauper idiots in 236,027 inhabitants, or 1 in 995; in Berkshire, 200 pauper idiots in 205,625 inhabiants, or 1 in 1028; and in North Wales, there is a pauper idiot for every 906 souls. With these figures before us it is of no use hiding our national skeleton; the closet-door is opened every year during the census of pauperdom, and the grim fact constantly increases. Possessing what we call the highest civilization, we European and North American nations produce more useless children than those savages who have little or no civilization.

We present, as peoples, indications of defective vital force, which are not witnessed amongst those human beings that live in a state of nature. There must then be something rotten in some parts of our boasted civilization; and not only a something which has to do with our psychology, but a great deal more with our power of physical persistence. It is a fact that the type of the perfect minded just above the highest idiots or the simpletons is more distinguishable amongst the most civilized of the civilized, than amongst those who are the so-called children of nature. Dolts, boobies, and stupids, *et hoc genus omne*, abound in young Saxondom, but their representatives are rare amongst the tribes that are slowly disappearing before the white man. We notice a wild flower, and observe that it flourishes in the woods, on the hill side, and down in the valley; its growth is magnificent and the reproduction is invariable. We transplant the flower into our gardens and care for it, and year after year its beauties remain in perfection; but if, in order to improve upon nature and to attempt to excite some hidden powers of growth, the plant is removed to the green-house and "cultivated," one system of vital phenomena invariably extends to the detriment of another. The vegetative and the reproductive systems are constantly antagonistic under the artificial treatment. You select splendid flowerers and strain every function to perpetuate the unusual inflorescence; but what occurs in the majority of cases? The outside is splendid, but everything else is sacrificed. You have outraged nature and have obtained the homologue of an idiot in a highly civilized community. It is the same with animals, and there is not much difficulty in "cultivating" any of our domestic pets until the progeny becomes stupid and very difficult to keep alive. Nature only cares for those organisms that possess all their functions in perfection, and the struggle for existence soon militates against those whose nutrition is defective or hard to influence. It is clear that there are some vices and defects in our civilization that are positively antagonistic to the production of a population perfect in mind and body, and negatively so also by evolving evil out of what is hardly otherwise than normal in so-called savage nations. The marriage of close relations, over-indulgence in food and spirituous liquors, continuous misery and moral degradation, hopeless poverty, over-work, agricultural drudgery, everlasting hebetude from the general sameness of surroundings, are amongst the proximate causes of congenital idiocy, and of that kind which develops itself in healthy children some time after birth, and which has similar phenomena.

The production of insanity and the development of idiocy are two different things, and it is one of the signs of the times that idiots are being separated from lunatics. The public mind still associates the two conditions, and the public purse is certainly well

opened for both. Some pathologists deny congenital idiocy, and assert that the healthy baby develops the disease by thumb-sucking, but experience proves to the contrary, and a long list of material cerebral defects and deformities indicates that although the laws of teratology are often beside the question, there are structural peculiarities sufficient to explain the mental condition. The following selected cases will give an idea of the vast amount of difference in the so-called idiotic. The first is the history of a profound idiot; the second refers to a case which had locomotive powers; and the third relates to a child that enjoyed slight communication with others.

A boy, six years of age, is a well-formed idiot of the lowest class. The head is not badly formed. The face is pale and is without expression. A slight smile is now and then seen when he is much pleased, but there is no evidence of intelligence to be derived from the action of any of the facial muscles. He stares fixedly, and will not follow the hand with his eyes when it is waved to and fro. His power of vision is very slight, and at times the eyes wander from one object to another in an unmeaning manner; or they remain fixed upon space while the head is slowly moved from side to side. The ears are well formed externally, and he hears, but will not listen when required to do so. The nose is well formed, and the sense of smell exists. His taste is defective, and he can barely distinguish between nice and nasty things. The saliva runs slightly from the mouth, which is usually open. The upper lip is large, the teeth are irregular and bad, and the arch of the palate is high. He has no voice, and cannot hum a tune, and he rarely shrieks or cries. The body is well made, but very weak in its muscular development. The lungs are healthy. The heart is very feeble in its impulse, and its pulsations are slow. The erect posture soon induces faintness. The arms are thin and well formed, and so are the hands. He can move the hands at will, but he cannot grasp in an easy and perfect manner; they are generally in motion, being waved in the air before the face. The legs are thin. He cannot stand nor sit upright. He can kick about and roll over, but the usual posture is on the back with the legs drawn up. He does not recognize his mother, there is no intelligence; the emotions barely exist, and even passion is rare. The habits are those of the earliest infancy. He has to be treated like an infant of a few days' old. He does not suck, but takes food from a spoon or with his fingers, but he cannot swallow unless the morsel is placed far back on the tongue. He sleeps well and drinks with difficulty.

The intelligence is at the lowest ebb, the power of muscular co-ordination is very defective, and the inability to walk or to use any of the limbs satisfactorily characterizes the case. The child

had not the spontaneousness of an infant a week old; and six years of care only produced the ability to sit up and to notice a very little. That the idiocy was congenital there can be no doubt. It was evidently so in the next case.

A female child, aged six years. The child is small, with a thin long body, high shoulders and extremities. The shape and size of the head may be gathered from the following measurements:—

	Inches.
Circumference	17·5
Nasal spine to occipital protuberance	11·5
Mastoid process to mastoid process	12·75
Great diameter	6·75
Small diameter	4·75

The forehead is very small. The face is small and pale. When quiet, there is nothing idiotic about the expression, but when, as is usually the case, she is restless, the mouth is noticed to be widely open, and the entire hand is often stuffed into it, the aspect being very silly. Considering her age, the expression of the face is very vacant. The eyes are large, and vision is imperfect. She looks about in a vacant listless manner, stares fixedly for a long time, and possesses barely any power of fixing the eyes to examine an object. The ears are large. She hears, but does not listen. The nose is well formed, and its sense is perverted. The mouth is very large, and the lips also; the teeth are irregular and the tongue is swollen. The saliva runs in quantity from the mouth, and there is much discharge from the nose. She makes unmeaning sounds, screams, and cries, but rarely laughs. She can sit up of her own accord, lie down, turn round, and stand in a curious stooping posture. She cannot walk slowly in a straight direction, but sets off one shoulder first, and, like a tipsy man, takes a staggering run to the left, then to the right, and so on. She usually brings her elbow close to the side, elevates the wrists, and allows the back of the hands to drop forward in running. The whole proceeding gives her the appearance of a rat. She cannot employ her hands in any useful manner. Automatic movements of the body, see-saw of the head from side to side, and of the hands before the eyes, are frequent. Constantly in motion, when not erect she twists her body and agitates her arms. She does not recognize those who are kind to her, does not care about her food. She cannot be made to attend, to listen, or to do anything. Her emotions are easily excited, and she will scream, open-mouthed, by the hour. Everything placed in the hand goes to the mouth without discrimination. The scalp is tender to the touch. She is quite infantile in her habits. She sleeps badly, and has great thirst. She can move about, and thus has more nervous force than the first case, but she has not the intelligence of a child a month old.

The third case is a male, aged eleven years. He is a slim, long-limbed boy, with a long and narrow head. The following are the head measurements :—

	Inches.
Circumference	19·5
Nasal spine to occipetal protuberance	12·5
Mastoid to mastoid	14·
Great diameter	6·5
Small diameter	5·5

The face is hideous, and is peculiarized by its constant contortions. The mouth being opened, shut, and twisted, the brow knit, and the whole head turned in the oddest manner. The skin is sallow, and is usually moist from the quantity of saliva flowing from the mouth. There is an expression of happiness when he is spoken to and noticed. He squints and suffers from fixity of vision, and also from restless movement of the eyes. He has a little power of directing his vision, but he looks at things out of the corners of the eyes, and lifts his chin obliquely in doing so. The ears, nose, and mouth are well formed. He hears, and can be made to listen slightly; moreover he notices music. He cannot speak, but howls, cries, and laughs. The muscles of the body and limbs are flabby. His arms are long, and the right wrist is bent upon the fore-arm. He is club-footed, can balance himself on his toes if held, and has much power over his limbs. He cannot walk nor stand alone. He balances himself when sitting, thrusts out his legs and arms, and presents a very singular appearance. He has but slight power of attention; he can discriminate between persons and different things, and he has therefore slight evidences of intellectual perception and memory. The emotions are easily excited. He knows his mother, his attendants, and those who often notice him. His habits are those of a child a few months old. He cannot do anything for himself. His meat has to be cut up small, and placed on the back of the tongue. The chin is then oddly rotated upwards, and the morsel is swallowed with difficulty. He knows his food. He rolls his head a good deal. In six years he learned to stand alone, and gained a little more intelligence, but he is still silent and a solitary.

These cases are those of congenital idiots, and the first is evidently lower than the last in the mental and physical scale. The gradation towards the more highly developed amongst the feeble-minded is pretty well exemplified in the following cases :—

A girl, aged fifteen years, is high-shouldered, has a large body, short limbs, and a small head. She sits with her head on one side, looking over one shoulder. The eyes are fixed upwards on vacancy, and the chin is poked forward and upward. When she moves from this position the chin is not lowered, and the attitude assumed is terribly simian. She walks badly, and she steps short, being lame.

She can run a little, and sits up; moreover, she can get in and out of bed herself. The features are irregular, the eyes are deep-set, and the nose is small and flat. The lower jaw is large and prominent at the chin. There is some power of expression in the muscles of the face. She squints with one eye, but sees well, being incapable, however, of having her visual attention directed. The eyes wander much, and are also often fixed with an unmeaning "brown study" stare. The ears are large, and their sense is acute. She is fond of music, and will listen sometimes. The senses of smell and taste are natural, and there is no excess of saliva. The hands are clumsy, and she can spoon her food, but she cannot dress herself. She makes herself useful by holding things. She has slight memory, which is restricted to persons and things with which she is in constant contact. She remembers a few names. She has a few ideas and fancies, and is very sensitive to external impressions, although the result is transitory. She has ideas of self-preservation, and is occasionally very passionate, but usually is placid, good, affectionate, and obedient. She is incapable of being taught anything, except a few household matters.

A girl, aged eleven years. She is tall and thin, and has a narrow and flat forehead. The face is large, and the mouth also. It is generally open, showing the ragged teeth, and permitting some slavering. The face is expressionless, the eyes are not often fixed, but the head is constantly turned about, looking for new objects. She has slight powers of speech. The body and limbs are well formed; the walking is very badly performed; the muscular co-ordination is defective, and she is much given to jerking movements. She is gay, very full of fun, and affectionate, and occasionally passionate. The memory is very weak, and the powers of comparing, of perceiving intellectually, and of attending, barely exist, but the attention can be attracted.

A girl, aged twelve years, has a small head with a high sugar-loaf shape, Chinese-looking eyes, and a long, projecting lower lip. The face is very placid, without expression when she is quiet, but there is much capacity for expression. The eyes are weak, and she stares long and fixedly; the nose is flat. She is lop-eared, but hears fairly well; she listens indifferently, and sucks her large tongue. The teeth are deficient and bad. The body is well formed, the legs are long and straight, but the arms are bowed. She walks and runs badly. She speaks a few words. The memory, perception, and attention are at a very low ebb. She is listless and sedentary, bashful, good-tempered, gay, and knows those about her. She is obedient, and knows what is expected of her.

A stout and well-made boy, aged eight years, has a well-formed body and limbs. The shape of the head is good, and the face is large. Its expression varies. The eyes are well formed, but he

suffers from wandering vision. The senses of hearing and smelling appear perfect. The mouth is large, and he slavers. He can hardly enunciate a syllable, but can sing slightly. His muscular co-ordination is defective, and he waddles in his gait. He is much below the standard of intelligence amongst perfect children of his age, yet he is high amongst the idiots of his class. He understands a great many words, and attends tolerably. His memory is very weak, but he remembers many things he is told to do. He knows his own things, he can compare, and he has a slight idea of consequences, but foresight and imagination do not appear to exist in his mental constitution. The intellectual perception is very slight. His attention is easily obtained. The emotions are readily excited. He is bashful, good-tempered, obedient, affectionate, and gay. He is restless and mischievous. He knows very little. He feeds himself with a spoon, but cannot dress himself. The dulness of comprehension is very great.

The following case illustrates the highest amongst the upper class of idiocy, but the man had been many years under supervision and training:—

A tall, powerful man, aged forty-four years. The face is expressionless and dull, but good-tempered. The special senses are perfect, and the speech is rather hesitating, but otherwise distinct. The body and limbs are well made and are on a gigantic scale: he is 6 feet 3½ inches high. The gait is slouching, but the general coordination is unusually perfect. His intellectual powers classify him high amongst the feeble-minded. In spite of careful training, his stupidity, obtuseness, slowness of comprehension, and defective power of perception are constantly noticed. Any trivial ailment diminishes the mental powers in a marked degree. He reads slowly and well; writing is moderately performed; he has slight arithmetical powers, and a good slow memory. He is very good-tempered and amiable, is obedient and placid as a rule, but easily roused, and religious. He is a very good son and a careful labourer. He requires looking after as regards his personal cleanliness. There is no relation in his work between the labour used and the degree of force required. He is generally incompetent when out of supervision. He works in the garden and takes messages. The want of spontaneity, the general dulness and slowness of comprehension, the slightly defective speech and the slouching gait, are very distinctive.

Most of the so-called idiots may be arrayed side by side with one or more of these cases, and the necessary restriction of the term to the most debased becomes very evident after considering the positive mental peculiarities of the latter examples. They all have some peculiarities in common. Thus a defective state of muscular coordination is invariable. The muscles may act well separately, but they do not combine their action properly to a common end. This is

in consequence of a grave nervous defect, and we owe the diagnostic to Seguin. It is very remarkable how writers who scribble about idiocy, without ever having had an opportunity of spending days and weeks with the unfortunates, and who display such arrogant ignorance of their subject when they review the labours of practical observers, invariably neglect to notice this great physiological defect. The idiot hears, but as a rule cannot enunciate a syllable correctly, and there is always a defect in the voice. Yet he may open and shut his mouth well, move his tongue properly, expand his chest, and cause some vibration of his vocal cords. But the complex association of movements to the common end of the production of voice is impossible from defective co-ordination. Again, no idiot walks or runs perfectly. The defective combination of the great number of muscles employed to produce graceful locomotion is evident. The greater the idiot, the more defective is the coordination of his muscles.

Automatic movements are also common to all the cases, and they bear a direct relation to the profundity of the idiocy. Such are balancing the body and waving the hands to and fro, moving the head from side to side, see-sawing with the body, moving like a pair of open compasses, first on one foot, then on the other, and going through all these unintentional gymnastics, one after the other, with fidgety regularity. The movements will go on hour after hour, and even for days. Fixity and wandering of the eyes and of vision are common. The child stares, in the first instance, upon vacancy, and the attention is not to be attracted; but in the last, the child moves its eyes listlessly hour after hour. The mental defects, want of regard of consequences, and want of foresight, are as evident as the absence of imagination and of all notion about abstract ideas. In idiocy there is not a weakened condition of a perfect mind, but many of the mental phenomena are not possible. The children have ears, and hear, but they do not listen. The memory of things is slight, but the recollection of events, and of time in respect to events, is rarely observed.

Sometimes one faculty is brighter than the others, and, dim as it is, it strikes the superficial thinker; but really the most brilliant gift of an idiot is far below the corresponding average of the perfect man of the same age.

The phenomena of idiocy are occasionally developed, in consequence of disease of the brain, in children and adolescents who were born in perfect possession of their faculties; but an amount of inanity is usually superadded, and of wild, odd wit also.

VI. THE FRENCH IMPERIAL SCHOOL OF FORESTRY.

By Alfred Pengelly, B.A. Cambridge.

At a time when we see fully recognized the importance of the maintenance of forests, both for commercial purposes and also for the great influence which they exert on climate, especially in tropical countries, it may not be uninteresting to the public to have set before them the steps which have been taken by the British Government for placing our Indian forests under careful and efficient management.

We learn from the Report of the British Association for 1868,* that at the meeting of this body in Edinburgh in 1850 a committee was appointed to consider "the probable effects, in an economical and physical point of view, of the destruction of tropical forests." Their Report was presented in 1851 at Ipswich, and is printed in the volume for that year. "Attention was thus directed in India to the importance of preserving every influence which tends to maintain an equilibrium of temperature and humidity, of preventing the waste of valuable material, and the special application to their various uses of the indigenous timbers of the country. A few years later forest establishments were sanctioned in British Burmah (1855), and in the Madras Presidency (1856); and in 1864 Government laid the foundation of an improved general system of forest administration for the whole Indian empire, having for its object the conservation of state forests, and the development of this source of national wealth. The appointment of Inspector-General of Forests was made, and it is now held by Dr. D. Brandis, formerly the able conservator in British Burmah."

It is through the combined exertions of Dr. Brandis and Dr. Cleghorn, the latter the author of the paper just quoted, that the plan of sending young men to France and Germany to undergo a special training in forestry has been adopted.

About the year 1866 Dr. Brandis visited the forests of England, Germany, and France, and the Forest Schools of the latter two countries, and, as the result of his observations, advised the Government to pursue the course just mentioned. In conjunction with the French and German authorities, he drew up regulations respecting the studies of the English pupils whilst at the Forest Schools.

At the end of 1866 our Government announced their intention of sending out five young men, duly qualified, for the Forest Department of India.

* 'On the Distribution of the Principal Timber Trees of India, and the Progress of Forest Conservancy,' by Dr. Hugh Cleghorn: 'Brit. Assoc. Rep.,' p. 91. 1868.

Candidates for these appointments were to undergo a preliminary examination in London in Arithmetic, Algebra, Trigonometry, English Dictation and Composition, the Natural Sciences, and Drawing. A knowledge of French or German was also required, and all the candidates had to pass a strict medical examination. Those who were successful were then sent either to France or Germany to study the science of Forestry, as taught in the old established schools there. It is to the course of instruction in the *Ecole Impériale Forestière*, established at Nancy, in the department of the Meurthe, that the present article will be devoted.

This establishment is an offspring of the German schools, having been founded in 1824, when M. Lorentz, who had studied Forestry in Germany, was made Director. It is not to be supposed, however, that the French and German systems are identical. Any one, reflecting on the characters of the two nations, would be prepared to find that the German system was more artificial, and entered much more into minutiæ than that pursued in France. At all events such is the fact.

Before the establishment of the Forest School in France the administration of the forests was carried on by officers of the army, detached for the purpose, but who had received no special training for the service. This is pretty much the state of things that has obtained in India up to the present time, such officers, however, being selected as were specially fitted for the service by their botanical or scientific knowledge.

Those candidates who were sent to France had to spend eight months at Haguenau, near Strasbourg, before entering the school at Nancy, partly to ensure such a knowledge of French as would enable them to follow, with facility, the lectures of the French professors, and to take copious notes of them; and partly to give them a practical knowledge of the operations which are carried on in a large forest, such as that of Haguenau. In November—the commencement of the scholastic year—they proceeded to the *Ecole Impériale Forestière* at Nancy, where, with the single exception of lodging in the town instead of at the school, they were submitted to the same regulations as the pupils of the French Government.

We shall now proceed to give a brief account of the course of study during the two years over which it extends. In each, the winter season is devoted entirely to lectures and study connected with them: a portion of each day is also devoted to drawing, either for the purposes of surveying, or the construction of bridges, saw-mills, &c. After Easter commences what may be called the practical or out-door part of the course, when the whole School goes out to see the forests, and generally to apply what has been taught in the lectures. During this time, in order to prevent

confusion, the School is divided into sections, each consisting of six or seven pupils, who work together, and are responsible only for that part of the task allotted to them. In some cases, as for instance in the Triangulation to be hereafter mentioned, the results obtained by the six or seven sections are combined on the return to Nancy, so as to form one whole.

The subjects treated of in the lectures may be classed under four heads:—Sylviculture, Applied Mathematics, Natural History, and Law. These lectures are carried on simultaneously, two subjects being taken on each alternate day. The Sylviculture treats first of climates, soils, and the different kinds of trees, giving their requirements, their natures, and the qualities of their timber. Then follow a description and discussion of the different methods which have been, or are still applied to the treatment of forests; in fact, a kind of introduction to the whole subject, giving a good general view, without entering into details. It must be remembered that many of the students have never seen a forest, and that therefore it is of importance to give at the outset a correct general idea of what a forest ought to be.

Under the head Mathematics is included all that is necessary for land-surveying, levelling, &c., the construction of houses for forest guards, and road-making.

The Natural History is confined to a course on Botany and Vegetable Physiology.

The Law treated of is an introduction to general principles, with a short course on the code respecting the chase.

For each of the four kinds of subjects there is a professor and an assistant-professor.

The following table shows the distribution of the work for the students of one year:—

	Monday, Wednesday, and Friday.	Tuesday, Thursday, and Saturday.
8—9.30.	Natural History	Study.
9.30—11.	Study	Sylviculture.
11—12.10.	Breakfast	Breakfast.
12.10—1.30.	Drawing	Drawing.
1.30—2.0.	Recreation	Recreation.
2.0—3.30.	Law	Drawing.
3.30—5.0.	Study	Mathematics.

For those of the other year the arrangement is exactly the same, except that the days are interchanged.

In order to ensure attention to the lectures, any student is liable to be examined during the afternoon study time on any subject treated of in the last ten lectures. The list of those to be examined is posted up every day at 12.10, so that a short time is granted for revision. These examinations occur irregularly; hence there is nothing to warn a student when he is likely to be examined. All

that he knows is, that, come when it may, it will be on one of the subjects to which the lectures for the day are devoted.

At the end of the lecture session, generally before Easter, there are examinations on the whole of each course. These, as well as those already spoken of, are *vivâ voce*, and in order to prevent partiality the questions are chosen in the following manner:—A book is published before the examinations commence, giving for each subject thirty sets of four or five questions, numbered from one upwards.

The student on arriving draws one of thirty numbers placed in a bag, and he is then examined on the set of questions indicated by the number drawn. The professors, however, reserve the right to ask a question not indicated in the set drawn. These examinations last from half to three quarters of an hour. For each there are three professors; one acting as president and the others as assistants. Each gives marks, and the average of the three estimates determines the final mark for each examinee. Every student has three clear days to prepare for each examination.

Marks are given also for all the drawings executed during the year. These, like those for the smaller examinations, count only for a proportion of their value, and are added to those given for the final examination in order to the determination of the class list.

The studies after Easter form the most enjoyable portion of the whole course. In the first year a month is spent at some place, such, for instance, as Gérardmer in the Vosges, where there are forests, portions of which are surveyed by the students, who are divided into sections, as already intimated. Immediately on the completion of the observation of angles and of the chaining, rough plans are made in order to detect and correct any grave error before leaving that part of the country, and more finished plans, combining the results of all the sections, are executed on returning to Nancy.

In this district, too, a road is planned out, each section taking a part of the work.

These practical operations are of very great importance, as they serve to elucidate what has been said in the lectures, and to impress each point more firmly on the mind.

After this comes the very best of the whole year,—the time spent in making a tour to see some of the principal forests of France. The parts visited are the Vosges and the Jura, and, of course, in this manner the school passes through some of the finest scenery of the country.

The object is twofold: first, to see the forests themselves; and secondly, to study general natural history, and to make a collection of plants for an herbarium.

The Professors of Sylviculture, who accompany the school,

describe the soil, climate, and position of each forest, the treatment to which it has been subjected, and the effects of the operations performed therein, praising the good and condemning the bad. The students take notes, which are to aid them in writing a memoir on returning to Nancy.

For the second object, the Professor of Natural History accompanies the school, and gives notes on all the geological formations which present themselves, and also on the different plants which he directs the students to collect. These are such as are found in forests generally, or which denote the presence of some particular soil. The effects of the ravages of different insects, with their modes of life, &c., are also pointed out.

On returning to the Forest School, a general memoir of this tour is made, and each student arranges his herbarium, labels being affixed to the specimens, denoting the place and date of finding, together with the class, family, genus, and species.

After all this has been finished, come the examinations for the end of the year. In these, questions can be put on any part of the course of lectures as well as of the practical course; or the student may be required to give a description of any forest visited, or to state where he has seen any particular fact illustrated. Marks are given for the examination itself. To these are added a proportion of those gained in the examination at the close of the lecture session, as well as of those for the exercises done in the practical course, and thus the place in the class-list for the year is determined.

The examinations are finished by the middle or end of August, when the vacation, which lasts until the commencement of November, begins.

In the second year, lectures are delivered on the same four classes of subjects.

Those on Sylviculture commence with a revision of the first year's course, and go on to describe the "Aménagement" of a forest. The "Aménagement" forms the basis of the management of each forest, giving, in fact, the plan on which it is worked, regulating the thinnings and clearings to be applied to it, the age at which the wood should be cut, and the amount that can be cut yearly without endangering the existence of the forest.

Perhaps the best idea of the meaning of the word "aménagement," of which there is probably no exact equivalent in English, will be gathered from the following definition given in the course at the Forest School:—

"L'aménagement d'une forêt est une opération qui consiste à régler le mode de traitement et les exploitations de cette forêt en vue des besoins du propriétaire et de la consommation," which may be anglicised thus:—The aménagement of a forest is an operation which consists in regulating the mode of treatment and the cuttings

in this forest, in view of the necessities of the owner and of the general consumption.

The Mathematical lectures consist of a course on Mechanics, with special reference to the different kinds of saw-mills and a short course on Triangulation and the use of the Theodolite.

Those on Natural History embrace three courses: one on Mineralogy, one on Geology, and one on Zoology. Of the last, perhaps the most important part regarding the forests is that which treats of insects and their ravages, and the higher animals by which they are kept in check.

The legal studies are restricted to forest law, treating specially of the French *Code Forestière*.

As in the former year, examinations are held constantly on the last ten lectures, as well as at the end of the lecture session and at the end of the year. They are conducted in the manner already described.

After Easter the school commences its travels, but there is now no real tour. The students go to some locality where the different kinds of saw-mills can be seen in action. Drawings of the machinery are made from actual measurements, and are coloured so as to indicate the material of which each part is composed. General directions are given to the students, and each is at liberty to take what sections he thinks most necessary. They are also to obtain all the information needful to determine the efficiency of each machine and the probable cost of construction, so as to be able to deduce its value as a commercial speculation.

The School is also required to make a triangulation of a tract of country, and for this purpose they adopt as a "base" some line which has been calculated by the Ordnance Survey of France, which would, of course, be more exact than one measured by the aid of ordinary instruments. In this triangulation the method of sections is again adopted, each having a certain number of signals assigned to it, and being responsible for the exactitude of the results obtained.

The practical application of the course on the "Aménagement of Forests" is generally made in the forest of Haguenau, which in one part consists of "hard wood," oak, hornbeam, and beech, the first being often remarkably fine; whilst the other part is almost exclusively composed of Scotch fir. The students have to form a plan for the "aménagement" of the portion of forest which is allotted to them,—generally from 1500 to 2000 acres. Of course, before proposing any scheme, it is necessary to know the contents and condition of the forest. In order to this, it is divided into parcels, homogeneous as to climate, soil, aspect, and also as to the kinds and ages of the trees found in them. Each of these is described, and they are then grouped so as to form masses which may as

much as possible be cut at the same period, and in such a manner as to satisfy the rules laid down for the good management of forests. Two of these "aménagements" are executed here; one in the "hard-wood" and the other in the Scotch fir. Another had before been effected in the forest of Haye, near Nancy, which has hitherto been treated as coppice, but is now gradually being changed into a real timber forest, in which the reproduction is to be effected by natural seeding. This "aménagement" had for its object to show how the change might be completely effected with as little loss and as much regularity as possible. These "aménagements" include the principal cases likely to occur in France.

In the principal Examinations of the second year the professors give specimens of rocks, plants, and wood to be determined. Respecting the plants the student is required to state the class, family, genus, and species to which each belongs.

For the final class-list a proportion of the marks gained in the first year counts with those of the final examination, which itself forms about half of the total, the other half being supplied by the marks of the first year, the marks at Easter of the second year, and those for the different exercises during that year.

These examinations bring the course at the *Ecole Forestière* to a close; and those who have satisfied the examiners have invariably been found perfectly competent for all their professional duties. Whether the system inculcated at the *Ecole Impériale Forestière*, with the modifications necessitated by the differences of climate, can be successfully applied to the forests of India, is the problem now awaiting solution.

The students who enter under the auspices of the French Government, must be between the ages of eighteen and twenty-two, thus resembling the majority of the undergraduates at our English universities. The contrast as to the discipline maintained in the two cases is very striking. From the table given above it will be seen that the whole day, from eight in the morning until five in the evening, is necessarily spent at the Forest School, for the students are not allowed to leave the premises, except during the hour devoted to breakfast. From five o'clock until ten in the evening they are at liberty to employ their time as they think fit, provided they do not infringe any regulation of the School.

The police of the establishment is carried on by three "Adjutants," one of whom is always in the room allotted to the men of each year during the study time; acting, in fact, as an usher, and reporting to one of the professors who holds the post of "Inspector of the School." The third has nothing to do in the School, but parades the town in plain clothes during the evening when the students are allowed to be out. The latter are obliged to return

to the School at or before ten o'clock, and to sign their names on entering. If the signature is not in the customary handwriting of the student, he is liable to be put under arrest, that is to say, he is not allowed to leave the School during a certain number of days.

Arrived on the premises, they are allowed to be in each other's rooms until eleven o'clock, but after that hour each must go to his own room and remain there. To ensure this, and for the maintenance of order generally, an adjutant makes his rounds on the staircases, and has the power to enter any room, after having knocked. At midnight he retires to his room at the foot of the staircase. The other adjutants do not lodge at the School. New buildings have, however, been recently erected; and in future they will all be lodged on the premises. The supervision is thus very complete; in fact, seen from an English point of view, the students are treated rather as boys, than as men responsible for their own conduct.

In order to represent the School on any public occasion, to maintain internal good order, and to decide differences which may arise among the students, a "Commission" of seven members is elected. It consists of a "President" chosen from and by the students of the Second Year, together with a "Papa" and two "Commissioners" chosen by the men of each year from their own number. The President has only a casting vote. The commission is recognized by the authorities, and through it hints are sometimes given to the students in a semi-official manner, which to some extent mitigates the pressure of the School regulations.

An hour on alternate days is devoted to regular instruction in horsemanship, but beyond this there is no athletic exercise, a fact which contrasts strongly, and perhaps disadvantageously, with English public schools and universities.

The English students speak most highly of the uniformly kind manner in which they have been received by the French with whom they have come in contact, whether professors or pupils; and it is to be hoped that the kindly feeling thus commenced will be constantly maintained.

VII. THE FULLER'S-EARTH IN THE SOUTH-WEST OF ENGLAND.

By RALPH TATE, Assoc. Lin. Soc., F.G.S., &c.

IN the early part of this year my honoured correspondent, M. Terquem, of Metz, applied to me for information respecting our Fuller's-Earth, as he was desirous to know the relations subsisting between the formation as developed in the province of the Moselle and in England. The account given of the Fuller's-Earth in our geological manuals is very meagre, and could serve very little my friend's purpose; but fully aware that such description did not embrace all that is known respecting the formation in this country, I had compiled the summary that here follows: and in addition supplemented our knowledge of the fossiliferous contents of the *terrain* by the determination of a large suite of fossils in the collection of the Geological Society. These new materials render no longer tenable the inferences that have been drawn on the affinity of the fossils.

The geological reader is aware of the great lithological and in part palæontological differences which exist in the Lower Oolitic strata at the opposite extremities of their range in England. In the belief that the present communication, brief though it be, is the fullest exposition of the history of the Fuller's-Earth in the south-west of England, I trust it will prove of service in future attempts to correlate satisfactorily some one of the members of the Lower Oolite of Yorkshire with that of the typical Fuller's-Earth.

I may state in passing that the Fuller's-Earth in the department of the Moselle has yielded more than 300 species of fossils, not including microscopic forms, which number nearly one hundred; M. Terquem* has divided the formation into three zones of life—the inferior characterized by *Ammonites Niortensis;* the median, by *Ammonites Parkinsoni;* and the superior, by *Ammonites Backeriæ.* No such divisions have been made out in the English beds.

Extent and Thickness of the Fuller's-Earth in the South-west of England.—With the other members of the Lower Oolite, the Fuller's-Earth has more or less of uniformity as regards its constitution and fossil contents from Dorsetshire to the borders of Oxfordshire. Throughout this tract, it presents an argillaceous character with thin beds of limestone and calcareous nodules. The underlying formation is, in every instance, the Inferior Oolite; but from the Dorsetshire coast to near Hinton, on the borders of Somersetshire and Wiltshire, it is overlain by the uppermost members of the Lower Oolitic series, and to the north of that locality the Great Oolite appears, and throughout the further extension of the Fuller's-Earth is the overlying formation.

* *In litteris.*

At Bridport, on the coast of Dorsetshire, the Fuller's-Earth attains a thickness of 150 feet; and near Bath, where it forms a conspicuous band, it is 140 feet thick; at Wotton-under-Edge, 128 feet; near Stroud, 70 feet; and in the north of Gloucestershire, as near Cheltenham, it is further reduced to a general thickness of from thirty to forty feet. It appears at Sherborne, near Burford, to the north-east of Cheltenham, and does not extend as far east as Oxfordshire, beyond which the Stonesfield slate rests on the Inferior Oolite. The horizontal extension of the typical Fuller's-Earth in the south-west of England, which is about 180 miles, is very much the same as that of the Upper Lias Sands—preserving a maximum thickness from Bridport to Bath, but attenuating rapidly to the north and east, and finally thinning out a little to the north-east of Cheltenham.

Lithology.—The peculiar mineral from which the formation derived its appellation, is confined to particular districts, as around Bath and Stroud, and where it does occur, constitutes but a very small portion of the thickness of the formation. This *Fuller's-Earth* is used in fulling cloth. The lithological characters of the formation may be gathered from the following sections:—

1. *Cliff at Watton Hill, west of Bridport Harbour,* "composed principally of blue clay, grey marl, and marlstone, with subordinate beds of imperfect stone; thickness of 150 feet; the base reposes on the Inferior Oolite, and the formation is covered by the Forest-Marble."*

2. *Bath,* in descending order:—

	Feet.
A. Blue and yellow clay, with nodules of indurated marl	30 — 40
B. Bad *Fuller's-Earth*	3 — 5
C. Good *Fuller's-Earth*	2·5— 3
D. Clay, containing beds of bad *Fuller's-Earth* and layers of nodular limestone and indurated marl	100
	135·5—148

Bed D encloses one or two strata of a tough, rubbly limestone, which is commonly called Fuller's-Earth rock, and bears considerable resemblance to Cornbrash. This rock is always accompanied by an immense number of *Terebratulæ,* and *Mya angulifera* and *Isocardia concentrica* are almost invariably found in it.†

3. *Slaughterford, East Gloucestershire:* ‡—

	Feet.
White marls, with occasional stonybands	25
White and grey limestone, and Fuller's-Earth rock ..	10
White and blue calcareous clays with *Terebratulæ* ..	30
	65 ‡

4. Near *Cheltenham.*—The deposit consists of regularly bedded blue and yellow shales, clays and marls, with occasional courses of

* De la Beche and Buckland, 'Trans. Geol. Soc.,' 2nd series, vol. iii. (1830).
† Lonsdale, Geol. of Bath, 'Trans. Geol. Soc.'
‡ Hull, Mem. Geol. Surv., sheet 34.

rubbly limestone or calcareous sandstone. Most of the limestones are a lumachelle, some of them being entirely composed of *Ostrea acuminata* cemented together.*

Palæontological Features of the Typical Fuller's-Earth.—The Fuller's-Earth does not possess a special fauna, and though regarded usually sterile as to the number of species, yet it is characterized by the profusion of *Ostrea acuminata, Terebratula ornithocephala*, and *Rhynchonella varians*. Professor Ramsay † summarizes the species of the Fuller's-Earth as follows:—Echinodermata 1, Conchifera 17, Brachiopoda 4. Total species 22, and remarks thereon:—"The majority of the forms that passed upwards from the Inferior Oolite limestone seem to have fled the muddy bottom of the Fuller's-Earth sea, and to have returned to the same area when the later period of the great oolite began .The Fuller's-Earth may be considered only as a comparatively unfossiliferous and inconstant lower zone of the Great Oolite." The inference stated in the first sentence of the quotation is not consonant with facts; for in the first place that portion of the Inferior Oolite which has furnished the larger proportion of Great Oolite species, and indicates similar conditions of deposition, is that of lower freestone beds and pea grit of Cheltenham, which occupy the base of the Inferior Oolite,‡ and in the second place, of the species common to the Inferior Oolite and Great Oolite, those which appear in the later stages of the former formation, occur also in the Fuller's-Earth. The second sentence of the above quotation is no longer applicable, inasmuch as though the fauna of the Fuller's-Earth is not exceedingly rich, yet far exceeds in number the then catalogued species, and, as I shall endeavour to show, has a greater affinity to the Inferior Oolite than to the Great Oolite.

The number of species catalogued by me from the Fuller's-Earth is 93, distributed in the following classes:—

Zoantharia	3	Gasteropoda	4
Annelida	4	Cephalopoda	10
Echinodermata	10		—
Brachiopoda	10	Total ..	93
Conchifera	52		—

So that the Fuller's-Earth is not so barren in species as is generally supposed. Of the 93 recorded species, two, *Montlivaltia tenuilamellosa* and *Belemnites parallelus*, have not been found in any other formation; and respecting the range of *Myacites Terquemus*, Buv, and *Pholadomya truncata*, Buckman, I have no information; 6 forms are at present undetermined, whilst the bulk of the species, 81, occur in either the Inferior Oolite or Great Oolite, or in both formations.

* Hull, Mem. Geol. Surv., sheet 34, p. 11.

† Anniversary Address Geol. Soc., 1864.

‡ See Lycett Cotteswold Club, vol. i., p. 71 et seq.; and Wright, Q. J. G. S., vol. xvi., p. 11.

The range of the 84 determined species is as follows:—

Peculiar to the formation	.. ..	2
Common to the inferior oolite and Fuller's-Earth	.. ..	33
" " great oolite " "	.. ..	13
" " three formations	.. ..	36

Accordingly, 69 species, or 83 per cent., occur in the Inferior Oolite, and 49 only, or 60 per cent., are found in the Great Oolite or superior formations. These results lead us to the inevitable conclusion, that the Fuller's-Earth is a subordinate member to the Inferior Oolite rather than to the Great Oolite, as hitherto considered.

The Inferior Oolite presents in its organic remains at least a twofold aspect, and whilst the older fauna is to some extent repeated in the Great Oolite, the newer fauna lived on during the deposition of the Fuller's-Earth, but did not extend into the Great Oolite. Indeed, the majority of the species common to the Fuller's-Earth and the Inferior Oolite made their appearance in time in the upper zones of the Inferior Oolite; such are:—*Serpula tetragona, Holectypus depressus, Hyboclypus gibberulus, Clypeus Plotti, C. Hugii, Echinobrissus clunicularis, Waldheimia ornithocephala, Terebratula perovalis, T. globata, Rhynchonella varians, R. spinosa, Cypricardia Bathonica, Ceromya Bajociana, C. striata, Goniomya angulifera, Isocardia nitida, Mytilus Sowerbyanus, Ostrea acuminata, Pleuromya æquata, Pholadomya Heraulti, Ammonites Parkinsoni, A. discus,* &c., &c.

And so close is the affinity subsisting between the fauna of the zone of *Ammonites Parkinsoni* and the Fuller's-Earth, that massing the species of these two horizons, the contrast in their numerical relations to those of the lower zones of the Inferior Oolite is as great as that which they present to those of the Great Oolite.

In conclusion, the Fuller's-Earth is not a *formation*, but only the uppermost, or a fourth, zone of the Inferior Oolite. Here, there is a marked decadence of Inferior Oolite species, yet at the same time the facies is decidedly after that fauna.

NOTICES OF SCIENTIFIC WORKS.

WROUGHT-IRON BRIDGES AND ROOFS.*

Of all materials used in construction in these days of progress, there is none which plays so important a part in engineering and architectural art as iron. This material has become the only resource of the engineer for carrying out those large designs and projects which thirty years ago would have been considered chimerical. The attempt to cross the Menai and Conway Straits with bridges formed of wrought-iron plates was treated by mathematicians and engineers as they would have regarded a chapter in the 'Arabian Nights;' and more than one eminent mathematician pronounced the attempt—however ingenious the combinations might be in the shape of iron plates—as a wild and fabulous scheme. It was only those connected with the preliminary experiments—which led to the form and principle of construction—who could form a correct idea of the project and establish with certainty the principle on which those important structures were founded.

It must be admitted that the position of the load and the form of its distribution were not attended to with the same mathematical accuracy as at the present day; but the general dimensions, extent of span, and weight of load were carefully considered, in order to resist every possible strain and to render the structures secure. All this was done in the face of detractors, and the doubts and fears of men of science, and the results are the completion of the Britannia and Conway Tubular Bridges, as they now exist, as firm and secure as the first day they were opened for public traffic. It is true that tubular bridges, such as the Britannia and Conway, are of a more expensive type than those subsequently introduced; but although extended practice and the progress of science may have suggested improvements, it cannot be disputed that all subsequent constructions of this kind are founded on the same principles as those to which we may safely refer as the pioneers of all their successors. We have a much greater variety in the forms of wrought-iron bridges now than when first introduced; but the principle, so clearly exemplified in the Britannia and Conway Tubular Bridges, is identical with more recent constructions in the balance of the two resisting forces of tension and compression, as exhibited in the upper and lower sides or flanges of those important structures.

* 'Wrought-iron Bridges and Roofs:' Lectures delivered at the Royal Engineer Establishment, Chatham. By W. Cawthorne Unwin, B.Sc. Associate Inst. C.E. E. & F. N. Spon.

Wrought-iron girders, whether tubular, plate, or lattice, are therefore simply modifications of what has already been done in the same direction, and provided careful attention is given to the quality of the material and soundness of the workmanship, we may rest assured of the security and permanence of every similar structure.

Many distinguished men of science have written treatises to elucidate the principles involved in the tubular and girder constructions, and among them may be mentioned Mr. Unwin, who has just published a report of his lectures on this subject, including a short treatise on the construction of iron roofs, delivered to the members of the Ordnance Corps at Chatham. As a lecturer on practical science a more efficient person could probably not have been selected, for—to a competent knowledge of mathematics applied to constructions—Mr. Unwin has had the advantage of five years' practical experience with Sir William Fairbairn of Manchester, and he therefore enters upon the discussion with a full knowledge of the subject on which he treats.

In the first lecture Mr. Unwin fully proves the advantages he has gained, by the competency with which he enters upon the investigation of stress and strain, bringing to his aid many apt illustrations, and by the graphic way in which he treats the principles of load and molecular resistances, greatly for the benefit of the student and those interested in the accuracy of iron constructions. To show the distinction between stress and strain, which means the force of the former applied to a material body, and the alteration or the resistance of the latter as a result, Mr. Unwin states, that the "strain is sensibly proportional to the stress for a range of about only one-third of the whole stress which may be applied before rupture ensues, if the bar has not previously been strained, and for a range of, perhaps, two-thirds of the breaking-stress, if the bar has not previously been loaded with nearly the whole breaking-weight. But in either case, with loads near the breaking-weight, the strain is not proportional to the stress, and the condition of perfect elasticity is not fulfilled. Hence laws derived from the consideration of a perfectly elastic material will not give accurately the ultimate resistance of structures of wrought iron."

The second lecture is devoted to the intensity of stress on bridges, and the methods of estimating the load and its limits of safety. It also relates to the weight of the structure and its load, or the dead weight and its live or rolling load. In this, as in the former lecture, Mr. Unwin gives some useful examples and illustrations of highly practical value to the student and engineer.

The third lecture treats of tubular, tubular-girder, and plate-girder bridges, showing the ratio of the top and bottom flanges to span, the depth of girder to span, and the method of designing, &c.

Lectures IV. and V. contain comparative examples of the Warren, lattice, and other kinds of bridges; showing also the direction of the strains of the lattice as compared with the solid web connecting the upper and lower flanges of the plate bridge. In this part of the investigation the author seems to demonstrate the theoretical advantages of the lattice or open web over that of the solid plate-girder, since in that system the bars may be inclined to the direction of the strains of tension and compression, which is not the case in the plate-web. There are, however, compensating advantages in the solid plate-web which appear to have escaped the author's notice in the increased degree of stiffness which is obtained in both the plate and the box girders. Many examples of this kind may be shown in bridges of long and short spans, and probably one of the best and most substantial of this sort is that over the Lune at Lancaster. The advocates for the open-web system have intimated the saving of weight at 50 per cent., but that statement is out of all question, as the only saving is in the difference between the open bars connecting the upper and the lower flanges in the lattice-girder, and the middle web connecting the flanges in the plate-girder, and which in the very best iron construction of that description is much nearer 6 or 7 per cent., and in some cases the difference is inappreciable.

The question of joints has been fully discussed by many writers; but the author brings under the notice of engineers the different modes of rivetting, and, without entering upon the merits of punched and drilled holes, he gives a mathematical analysis of the different processes which enter into the maximum strengths and forms of rivetted joints.

On Roofs.—Lecture VI.—Mr. Unwin states that "in the supporting framework of roofs precisely the same mechanical problem is presented as when a railway or roadway is to be carried over a ravine or river. Hence it is that the successive combinations adopted for bridges reappear, in essentially the same forms, as roof principals. The stone-vaulted inner roofs of some of the older churches are structurally identical with masonry bridges. Timber roof-trusses are simply awkward-shaped girders, or, like the great roofs at King's Cross and over the transept of the first International Exhibition, they are timber arches analogous to those frequently erected as bridges in the earlier history of railways. Nor is the case otherwise with iron. All iron roofs may be classed as girders or as arches, with certain transitional forms which embody the features of both classes. And to pursue the analogy farther, even the suspension principle, which at first sight, from the nature of the supports required, would seem inapplicable to the purpose, is, according to a proposal of MM. Lehaitre and De Montdesir, to be pressed into the service of the roof-builder."

Of the construction of roofs many examples are given, and the strains on the parts of different forms are carefully worked out in spans varying from 15 to 240 feet. The methods of determining the strains for differently formed roofs are exceedingly well adapted for obtaining perfect security, and the clear and distinct manner in which the subject is treated must be highly edifying to the student and practical engineer.

We might enlarge on this, but it could not be expected that a subject of such importance as Iron Roofs and Bridges could be successfully treated within the limits of a few lectures. There is, however, sufficient matter contained in the work before us to recommend its perusal to the consideration of the practical architect and engineer; and looking at the clear and graphic style in which it is written, we feel indebted to the author for this addition to our knowledge of practical science.

Habit and Intelligence, in their connection with the Laws of Matter and Force: a Series of Scientific Essays. By JOSEPH JOHN MURPHY. 2 vols. London: Macmillan & Co., 1869.

THE intricate problems of the genesis of animal and vegetable life, and of the connection between the human mind and its material abode, will ever be among those which engage and fascinate our intellects of the highest order. The doctrine of a gradual evolution of life, as opposed to that of distinct specific creations, with which the great name of Darwin is associated, and which has been elaborated by Spencer, Wallace, and Hooker, has of late years received an extraordinary impulse; while the parallel theory of a "physical basis of life" has obtained the sanction of some of the highest names in natural science. While these theories are doubtless founded on a substratum of truth unknown to our older naturalists, they are probably mixed up with a considerable amount of error and over-statement, which further investigations will remove. We therefore cordially welcome a work in which the problems of organic life are treated with so free and independent a hand, and with such close reasoning applied to a wide knowledge of facts, as we find in the volumes before us. While adopting the view of the evolution of all living organisms by descent, with modifications, from a few, if not from a single germ, Mr. Murphy holds that the Darwinian theory of Natural Selection from spontaneous variations is inadequate to account for the major part of these modifications, and altogether rejects the Huxleyan principle that the phenomena of life can be accounted for and explained on purely physical principles.

The first volume of this series of Essays is occupied with

a consideration of the laws which govern the material world, and a comparison of them with what we know of those which prevail in the domain of organic life. With great acuteness and force of illustration, Mr. Murphy points out that while it is a feasible hypothesis that many of the structures which we see in the animal and vegetable worlds are attributable to Natural Selection, or "the Survival of the Fittest," acting through a long course of generations, there are others which it is impossible to conceive can have become developed through the operation of this law, or of that promulgated by Herbert Spencer, depending on the mechanical adaptation of structure to function by the force of external agency. To this category belong such organisms in the vegetable kingdom as the hard, woody shell that protects the nut, but still more conspicuously all the most complex organs of the higher orders of animals. We will give the argument in Mr. Murphy's own words:—

"There are structures for the origin of which it is, I believe, utterly impossible to account by any merely physical theory. I refer to such organs as the eye and the ear. If it is certain, as I think it is, that the flow of the nutritive fluids through cellular tissue, for successive generations, must have a tendency to form a rudimentary circulating apparatus, it is at least equally obvious that the action of light falling on the eye for any number of generations, can have no similar tendency to produce the optical apparatus of the eye. Nor can the constant exercise of the eye in the act of seeing have any such effect. The exercise of the eye, within the limits of what is healthful, does, no doubt, tend to increase the sensitiveness of the retina; and I do not say it is impossible, though I do not admit it as probable, that the muscular arrangements to which the mobility of the eyeballs and eyelids is due, may have been produced by the effort to move them, continued through successive generations; and that the expansion of nerves over the retina may have been produced by the constant stimulation of the nerves themselves. But no such merely physical theory will account for the origin of the special complexities of the visual apparatus. Neither the action of light on the eye, nor the actions of the eye itself, can have the slightest tendency to produce the wondrously complex histological structure of the retina; nor to form the transparent humours of the eye into lenses; nor to produce the deposit of black pigment that absorbs the stray rays which would otherwise hinder clear vision; nor to produce the iris, and endow it with the power of partly closing under a strong light so as to protect the retina, and expanding again when the light is withdrawn; nor to give the iris its two nervous convexions, of which one has its root in the sympathetic ganglia, and causes expansion, while the other has its root in the brain, and causes contraction."

Admitting, then, as Mr. Murphy does, the premiss of the

common ancestry of all organisms, by what process is it possible to account for the gradual evolution of a being with so complex an organ as an eye from the primordial homogeneous and amorphous *Amœba* or *Gromia?* He sees the explanation in the co-existence with the vital principle of an Organizing Intelligence, consciously present in the mind of man, unconsciously in all organized structure. He believes that "the wondrous fact of organic adaptation cannot have been produced by any natural selection, or by any unintelligent agency whatever;" that "wherever there is life there is intelligence, and that intelligence is at work in every vital process whatever, but most discernibly in the highest." The recognition of this Organizing Intelligence running throughout organic nature, is the keystone of Mr. Murphy's system. The unconscious intelligence by which the bee stores up food for the sustenance of the larvæ, and builds cells for its reception on mathematical principles, is the same principle as the unconscious intelligence which has given it the organs necessary to collect the honey; the conscious intelligence in the mind of man which has manufactured the microscope is the same principle as the unconscious intelligence which in his body has manufactured, or, to coin a word, has "mentefactured" the lenses of the eye. The reasoning that the eye cannot have been produced by the action of mere natural selection is strengthened by the forcible argument that this latter view presupposes that the same selection from a long series of *spontaneous* variations has taken place in three separate lines of descent, in the Annulosa, the Mollusca, and the Vertebrata, the higher forms of which can, on no plausible hypothesis, have descended directly from one another, or from a common eye-possessing ancestor. Spencer's theory that all structures have been produced by adaptation to function in the individual aided by natural selection in the generation, is combated by the equally powerful argument that "as we ascend in the scale of nature to higher and higher vital functions, and higher and higher organic forms, we find the relation of cause and effect becoming less traceable by our faculties (though no doubt it exists all through nature); while at the same time the relation of means and purpose becomes at once more traceable and more definite. Nowhere in the universe, as known to us, is the relation of means to purpose more clearly traceable and more perfectly definite than in the organs of special sense in the higher animals, especially in the eye and the ear; and nowhere is it more difficult (I would say, utterly impossible) to assign any physical cause for the facts, than when we inquire by what cause, or by what agency, such wonderful organs have been formed. This truth, that purpose is most clearly discoverable where cause is least so, has not received the attention it deserves."

In his second volume Mr. Murphy enters upon the recondite subjects of Psychology, and especially of the relation of the mind to

the physical system and to the vital organization. The same mode of reasoning is applied as to the facts of organic life, and an analogous conclusion is the result. As the phenomena of animal and vegetable life cannot be referred to the operation of Natural Selection, or of any unintelligent agency whatever, so Mr. Murphy maintains that in all mental intelligence there is an element not derived from habit, and not resolvable into any unintelligent force; and is hence at issue with the psychological school represented in this country by Mill, Bain, and H. Spencer. In other words, "life, intelligence, and the moral sense is each incapable of being resolved into anything lower than itself." We cannot follow Mr. Murphy over the oft-trodden ground of the existence or non-existence of Innate Ideas—which he believes to be the inherited experience of the race, the reality of our belief in an external world, the origin of our conceptions of time and space, and other cognate speculations, on some of which he contrives to throw new light; but we wish rather to comment on one portion of his scheme which we take to be erroneous. Mr. Murphy points out clearly the difference between conscious and unconscious Sensation, and between conscious and unconscious Thought, the greater part of our thought being unattended by consciousness; but he often confounds, as we think, between conscious and unconscious Volition. Now we would maintain that nothing in our mental constitution is clearer than that the Will is often, and indeed generally, exercised without any consciousness of its action. The movements of the limbs in walking we presume Mr. Murphy would call, and we think erroneously, consensual action, the result of habit. The motion of the heart, of the eyelids, of the chest in breathing, we hold to be truly either consensual or reflex; and the test we would apply is that they cannot be arrested, or only to a very inconsiderable extent, by the action of the Will. In walking, on the contrary, we can stop at any moment we please; and whatever can be arrested by the Will must have been set in motion by the Will. The view has been held that in the motion of the limbs in walking, a certain storage, as it were, of voluntary action, is set at work at the commencement, which is continually flowing forth at every step without any fresh volition. But this idea, we think, will not bear a careful scrutiny. Take the instance of the slight inclination of the body to one side necessary in turning a corner; this cannot be done without the exercise of the Will, and yet we are perfectly unconscious that any such motion is performed. Or we may illustrate our argument by the familiar example of a flight of steps, say twenty, which we are accustomed daily to descend, and which has been shortened by one step at the bottom of the flight. We all know the unpleasant jerk given to the body by the foot coming into contact with the ground with greater force than was expected. We cannot suppose that an amount of voluntary energy was stored up when we commenced the descent

sufficient to carry us down exactly the twenty steps; it is evident that the Will was set in motion to descend the imaginary twentieth step with as much force as it was at the first step. But the best illustration of unconscious voluntary action is perhaps afforded by the motion of the fingers in writing, where the warmest advocate of the theory of habit can hardly maintain that the action is entirely consensual; and the storage of the Will hypothesis is evidently inadequate to account for each separate motion of the fingers, which must require a distinct action of the Will, exercised perfectly unconsciously to ourselves. The lateral motion of the eye-balls, again, which takes place in reading, is one evidently entirely under the control of the Will, and is yet performed with the most perfect unconsciousness.

We appear to have dwelt rather on those points in which we differ from Mr. Murphy than on those in which we agree with him. There is, however, much in these two volumes that will interest every student of Biology and of Psychology, and not a little that must commend itself to the attention of every man of science. Whatever acceptance his views may meet with in the scientific world, it is impossible not to acknowledge the fairness and moderation with which he has brought them forward, and the ability with which he has supported them by logical argument and by a large array of facts.

JEFFREYS' BRITISH CONCHOLOGY.*

From the various reports which have from time to time appeared in these pages, of the dredging expeditions of the author of this work, as well as from the notice of the second volume of a portion of the work itself, which is to be found as far back as in our first volume, our readers will have become well acquainted with the active labours of Mr. Gwyn Jeffreys. The publication of the work has extended over seven years, and all we can attempt to do here is to give a brief outline of its contents.

The first volume deals with "land and fresh-water shells," the remaining four with "marine shells;" but from this it must not be inferred that the author's labours have been confined to the description of shells alone. The book is an excellent and complete treatise on the Natural History of British Mollusca, containing not only accurate descriptions of the various genera and species in their zoological order, but accounts of their British habitat, as well

* 'British Conchology; or, an Account of the Mollusca which now inhabit the British Isles and the Surrounding Seas.' In 5 volumes (commencing 1862 and ending 1869). Illustrated with coloured and plain plates. By John Gwyn Jeffreys, F.R.S., F.G.S., &c. Van Voorst.

as of their geographical distribution. In addition to these details, the work is rendered interesting by such anecdotes and considerations as are calculated to relieve the tedium of study, and we have here and there incidents concerning the different kinds of molluscs, which form an agreeable diversion from the consideration of their anatomy, the form and colour of their shells, and the divergences of species.

In speaking of Helix aspersa, the author tells us* "they make great havoc in kitchen gardens, and spoil the best wall-fruit. There is, however, some compensation for this mischief: a kind of broth is made from them, and used as a remedy for pulmonary complaints. This kind of snail is occasionally eaten by the French; but it is not held by them in the same estimation as the Apple-Snail. Dr. Gray says that the glassmen at Newcastle, once a-year, have a snail-feast, and that they generally collect the snails themselves in the fields and hedges the Sunday before feast-day."

Nor are the author's considerations on the subject confined either to the scientific or the utilitarian, if feasting on snails can be thus designated. He sometimes soars into the regions of poetry; or, as he calls it, the æsthetical. The snail could never secure a footing on Mount Parnassus, he tells us, but "we may enter the realms of phantasy and we shall find it among those intruders which had to be chased from the cradle of the fairy-queen." Homer did not disdain to use the snail's shell as a helmet for belligerent frogs, in his "mock heroic poem." "The most imposing appearance," the author tells us, "which the animal has made in literature," is to be found in Goethe's "wild vision of the Walpurgis Night," when, on the top of the Harz mountains, "an adventurous and preternaturally sensitive snail," "detected the presence and unmasked the incognito of not less a person than Mephistopheles himself." And the author gives us the quotation, describing the occurrence, which leaves no doubt that the snail must have been very preternaturally sensitive, for it was able to smell out the identity of the Evil One with its tentacles!

However, we do not suppose the author had any intention to press the great German poet into the service of science, so we will let that pass.

The first volume of the work treats, as we have said, of land and fresh-water shells; the second, of the marine molluscs, comprising the Brachiopoda and part of the Conchifera. In the third, the Conchifera are concluded, and the Solenoconchia and part of the Gasteropoda treated. The fourth continues the description of the great group Gasteropoda, which is concluded in the fifth volume, where also an account will be found of the higher molluscs, the Pteropoda and Cephalopoda.

* Vol. i., p. 183.

Each volume is accompanied with a beautiful coloured plate as a frontispiece, and numerous well-executed lithographs. It suffices to say that the whole work is produced in Mr. Van Voorst's best style, and will form a valuable addition to his well-known treatises of reference on Natural History.

SCHRAUF'S HANDBOOK OF PRECIOUS STONES.

To any one who is not familiar with the elements of mineralogy, a cabinet of precious stones—however rich and rare—has no more educational value than a collection of shells can have to a person ignorant of the anatomy of the mollusca. Yet it is by no means needful to plunge into the depths of mineralogic lore in order to appreciate the scientific value of a gem. All that is necessary is a moderate acquaintance with the physical and chemical characters of the comparatively few minerals which rank as precious stones, and of those substances which are likely to be mistaken for genuine gems. Dr. Schrauf, of Vienna, has recently published a text-book,* which gives, within a moderate compass, all that mineralogical information which the collector ought to have at hand.

The early chapters of the work are devoted to a discussion of mineralogical physics—a subject which no one can handle better than the author of the elaborate *Lehrbuch der physikalischen Mineralogie.*

Popularly, yet accurately, he tells us all that we need know on the crystalline form of minerals, their hardness, density, thermal, electric, magnetic, and optical properties. Then follows a chapter on the forms in which precious stones are commonly cut by the jeweller. Each gem is then described separately, in order of value, commencing, of course, with the diamond.

In the chapter on Diamond, our author proposes a new formula for determining the value of this stone—a formula which is said to give results coinciding with the present market value of diamonds, and is, moreover, applicable to stones of high weight. Let a denote the current price of *one* carat; then the value of a diamond weighing m carats will be, according to Schrauf's formula,

$$\frac{m}{2}(m+2)\,a.$$

To illustrate the application of this rule, we may calculate the value of the celebrated Sancy diamond, which was sold only a year or two ago, and to which so romantic a history is attached. This

* 'Handbuch der Edelsteinkunde,' von Dr. Albrecht Schrauf. Wien, 1869. Pp. 252.

diamond is said to weigh about 53 carats, and being only rose-cut, one carat may be valued at 15*l*. Then, according to our rule, the value of the diamond may be thus expressed in pounds:

$$\tfrac{53}{2}(53 + 2)\,15 = 26{\cdot}5 \times 55 \times 15 = 21{,}862{\cdot}5.$$

It must be admitted that this is a tolerably near approximation to the true value, when it is stated that the diamond was sold by Prince Demidoff to Sir Jamsetjee Jejeebhoy for 20,000*l*.

Perhaps the most useful part of this work is to be found in the concluding chapters, which explain the method of determining an unknown gem, the results of which are afterwards collected in a tabular form.

We shall be glad to see so excellent a work as this translated into English.

SENFT'S MINERALOGY AND LITHOLOGY.*

If one branch of natural science, more than another, deserves to find a place in any improved scheme of scholastic education, that science, according to Dr. Senft, is undoubtedly Mineralogy. For, apart from its practical value to all whose daily occupation brings them into contact, directly or indirectly, with the products of the mineral kingdom—such as the miner, the builder, the agriculturist, and the manufacturing chemist—the study of mineralogy is so closely connected with that of many collateral sciences that a course of mineralogical lectures, properly delivered, might be made the means of imparting to a class much valuable information on the sciences of chemistry, physics, and geology, to say nothing of solid geometry. Hitherto this relation of mineralogy to other branches of science has been regarded as a great stumbling-block to the student, inasmuch as he must needs acquire a rather wide range of knowledge before he can successfully cope with the difficulties of mineralogy. These difficulties may, however, be removed, to a great extent, by an attractive style of instruction, adapted to the capacity of the pupil, but at the same time not superficial enough to nullify the efficiency of mineralogical study as a means of intellectual training. Five-and-twenty years' experience in teaching science to youths between fourteen and sixteen years of age, has led our author to mature a scheme of instruction which he regards as best adapted to meet the wants of those who may not wish to push their mineralogical studies beyond a very moderate acquaintance with the more important species. He devotes to this study only two hours weekly, but he extends the course over two years. The

* Lehrbuch der Mineralien und Felsartenkunde. Von Dr. Ferdinand Senft 8vo. Jena, 1869. Pp. 656.

first year's course is only preparatory, and chiefly chemical. The student first learns the properties of the elements, and thus becomes, to some extent, acquainted with the characters of such species as the diamond, graphite, sulphur, and the native metals. He then advances to the study of simple chemical combinations, and is thus made acquainted with the chief acids and metallic oxides. This chemical course occupies a summer session, and is followed, during the succeeding winter course, by the study of the physical properties of minerals, as demonstrated on certain species of simple composition. Our author's mode of teaching may be illustrated by an example of his lesson on Quartz. A piece of common quartz is exhibited to the class, pulverized, and treated successively with water and the ordinary acids, for the purpose of showing its insolubility in these reagents. A small quantity is then mixed with an alkaline carbonate, and slowly heated for a quarter of an hour in an iron capsule. The effervescence consequent on the expulsion of the carbonic gas points to the acid character of silica; while the formation of a vitreous silicate illustrates the chemical composition of glass. During these experiments, an apt teacher will, of course, entertain his class by a valuable lesson on the manufacture of glass, and by explaining the method pursued in the analysis of siliceous minerals. Having thus become familiar with the chemical characters of the species, a well-formed piece of rock-crystal is exhibited to illustrate its crystalline form. The six-sided prism and its two terminal pyramids furnish a text for much instruction on the crystallography of the hexagonal system, whilst models of the forms are made in clay before the class, or, still better, by the students themselves. Attention is then directed to the other physical properties of quartz: its hardness is shown by its resistance to the knife, and by striking sparks with steel; its specific gravity is taken; its phosphorescence exhibited; and electricity is developed by friction. In this way the student becomes interested in chemical and physical science; and if no other scientific study be introduced into a system of general education, much solid instruction can be imparted by a judicious study of our common minerals.

The second year's course comprehends work of a more strictly scientific character, and includes the principles of classification and a description of the more important mineralogical species.

To supply a work adapted for instruction of this practical kind, Dr. Senft has prepared a useful Text-book of Mineralogy and Lithology. The first part is devoted to the general principles of mineralogy; the second, to a description of the principal species; and the third, to the study of rocks or aggregates of minerals. In the notice of species those only are described which have acquired importance by their wide distribution, by their applications in the

arts, or by their functions as rock-constituents. A few rare species are, indeed, described, but only on account of certain marked peculiarities, either physical or chemical. Two plates of crystalline forms bring the work to a conclusion.

Vegetable Teratology: an Account of the Principal Deviations from the usual Construction of Plants. By MAXWELL T. MASTERS, M.D., F.L.S. London: Published for the Ray Society, 1869.

THE attention which Dr. Masters has for many years bestowed on abnormal developments of the various organs of plants, renders this last publication of the Ray Society from his pen a peculiarly valuable one. The importance of a study of teratology, both to the morphological and to the systematic botanist, in determining not only the true relationship of organs to one another, but the structural position of difficult orders, has only recently been acknowledged. Moquin-Tandon's has been heretofore the standard work on the subject, but is completely out of date in the light of modern research; since his time St. Hilaire, Morren, and others have investigated the subject; but up to the present time nothing of importance has appeared in this country, except a very old treatise by Hopkirk.

The classification of a number of facts necessarily so unconnected with one another as monstrosities and irregular growths presents considerable difficulties; in our present imperfect state of knowledge of the causes of these variations from typical structure, we think Dr. Masters has done wisely in adopting in the main Moquin-Tandon's somewhat empirical arrangement, rather than attempting one with more claims to a philosophical basis. He arranges the phenomena under four heads:—1st. Deviations from ordinary arrangement, including union or independence of organs and alterations of position; 2nd. Deviations from ordinary form; 3rd. Deviations from ordinary number, whether increased or diminished; and 4th. Deviations from ordinary size and consistence, including hypertrophy and atrophy. Under any classification a certain amount of repetition is unavoidable; but is probably as small under the one here adopted as could reasonably be expected.

The work does not profess to be a philosophical treatise on the causes of aberration from typical form, but rather a chronicle of the most important instances which have come under the notice of the writer himself and of other observers; and the immense variety of these deviations from the usual construction of plants must astonish the casual observer. We have well-authenticated examples, for instance, not only of the comparatively common transformation of

sepals into petals, or of complete suppression of the calyx or corolla, but of the far rarer production of ovules within the anthers, in the case of a *Cucurbita*, and of pollen within the ovules in the instance of a passion-flower. Scarcely less curious is the formation of a flower-bud within the pod in the charlock, and of a miniature siliqua in the place of a seed in the wall-flower. Of greater practical importance than these strange abortions, are the minor irregularities in the less vital organs, constituting the possible origin of new races that have obtained predominance in the "struggle for existence." To the physiologist who devotes himself to the investigation of the causes which lead to the production of abnormal forms, and of their connection with the origin of species, Dr. Masters's volume will be an invaluable repertory of facts. We cannot too highly commend the care with which the innumerable instances that must have come before him have been sifted, and those selected which are undoubtedly authentic, and which may be considered as typical; or the labour which has been bestowed on the bibliography of the subject, consisting mainly of separate articles and descriptions in the various English and foreign botanical magazines, collated under the different heads into which the book is divided. The volume is illustrated with upwards of 200 capital drawings by E. M. Williams; many of the best of which have already appeared in the pages of the 'Gardener's Chronicle' and other publications. We are glad to hear that a translation of the work into French is already arranged.

Cyclopædic Science Simplified. By J. H. Pepper. London: F. Warne and Co., 1869.

Professor Pepper has not only distinguished himself by the eminently practical way in which he has converted the Polytechnic Institution from a losing to a paying speculation, by discovering the proper combination of electricity, conjuring, dissolving views, chemistry, ghosts, and comic songs—a sort of scientific Punch, in fact—which draws the largest audiences; but he has brought the same talents to bear upon literature, and has given to the world, at intervals, three books—'The Play Book of Science,' 'The Play Book of Metals,' and the one now under our notice. Looking at these books from a highly scientific stand-point, we have no doubt much fault might be found with each of them; but from the point of view of that large section of the public whom Professor Pepper addresses, it would be difficult to say how they could be greatly improved. The present book embraces Light, Heat, Electricity, Magnetism, Pneumatics, Acoustics, and Chemistry. In each of these subjects, a large amount of information, generally of the

newest character, is given; the original papers on the various subjects as read before the learned societies being copiously quoted. As the author is almost bound, he gives full details of the various illusions and scientific tricks, ghostly and tangible, which have tended so much to popularize the Institution with which he is connected. The illustrations are numerous, and valuable in many cases, possessing an interest to men of the highest attainments in their respective spheres; and the initial engravings to the chapters are in many cases portraits of eminent philosophers. Thus, on page 197 we have James Watt, with autograph; at 392 is one of the best portraits we have ever seen of Sir Charles Wheatstone; on page 527 is an excellent portrait of Faraday; and at page 578 is one of Sir David Brewster. In addition to these, there are over 530 woodcuts, some of most elaborate description, and a chromolithograph as frontispiece, in which the author is exhibiting to an astonished audience the wonders of spectrum analysis, on a scale of magnitude never before witnessed.

Taking all things into consideration, we have no hesitation in saying that 'Cyclopædic Science' is one of the best books for boys we have ever met with. Its intrinsic attractiveness will do much to give a taste for science, and lead to a spirit of inquiry which will not be satisfied until the young philosopher possesses an experimental laboratory of his own.

CHRONICLES OF SCIENCE,

Including the Proceedings of Learned Societies at Home and Abroad; and Notices of Recent Scientific Literature.

1. AGRICULTURE.

The past three months have bristled all over with topics of agricultural interest — many of them, unfortunately, involving disagreeable experience. It is certain, now that a large portion of the wheat crop has been threshed, that the harvest of 1869 has been very much below the average productiveness of past years: and the low prices which wheat commands, owing probably to no one wanting corn in the general market of the world except ourselves, whatever their benefit to the nation at large, have materially aggravated to English farmers the injury of a deficient yield. —The foot and mouth disease—a cattle plague of more or less virulence and frequency ever since 1839, when it first appeared—has been unusually general and severe during the past autumn. It is now, however, believed to be on the decline. Though rarely fatal, it is a painful malady, stopping the milk of cows and wasting the flesh of fatting cattle, and thus destroying the property of stock owners. It is generally supposed to be an importation from the Continent; but though that probably was true thirty years ago, it can now hardly be doubted that the disease has become indigenous. Careful quarantine, both at the ports of debarkation, and in home localities wherever it exists, has, however, all along been urgently demanded, and it has been at length conceded, so that we may hope to see the evil reduced within less serious limits.—The miseries of cattle transit, whether by land or by sea, have been urged on public attention, especially by the interest which Miss Burdett Coutts has taken in the subject. The use of a railway cattle-truck, in which live stock shall have access to both food and water on a long journey, is most desirable; and it is believed that the inferior condition in which cattle after a railway journey reach the metropolitan market from great distances, when they have had no refreshment on the road, must at length make consigners of such cattle willing to pay the expenses involved in the provision of better accommodation. An experiment directed by Miss Coutts, in which six cattle were sent from Edinburgh to London, shows that cattle will eat and drink upon the way with great comfort to themselves and great advantage to their owners, if they have the opportunity.—The condition of Ireland, which is to a great extent an agricultural question, has of late occupied the public mind more painfully than any other

topic. Among the most valuable and suggestive of the many pamphlets which have been lately published on this subject is one by Mr. James Caird, in which he insists upon the curative influence of the lease of land for a term of years, as that which by its proved effect elsewhere is more likely than any other agency within our reach to be serviceable in Ireland. The Lothians of Scotland, which are the very model farm of British agriculture, were a century ago as badly off as Ireland is at present. Since 1780, owing chiefly to "enabling laws" affecting the condition of strictly entailed estates, the principle has become established, and the practice has become universal there, that the duty of the landlord is to provide the farm with buildings and other permanent improvements, and that the duty of the tenant is to find the capital for cultivation under the security of a lease for a fixed term of years. It is the influence of the lease for a term of years that has been so wonderfully illustrated in Scotland; and Mr. Caird would accordingly confine all Government assistance in land-improvement to estates and farms let on lease; and in other ways he would urge on Irish landlords and Irish tenants the acceptance of the lease, certain that it would create fertility and ensure industry and promote contentment in Ireland, as it has elsewhere.—A very striking picture of foreign agriculture has been drawn by Mr. James Howard, M.P., in a lecture before the London Farmers' Club. He has proved conclusively that the small-farm system prevalent in many continental countries is greatly inferior to our own plan of large holdings in almost every particular in which they admit of comparison. In the actual maintenance of a large population directly on the land we presume the former must be acknowledged superior; but the condition of both occupier and owner under such circumstances is shown to be below that of the English farm-labourer, while the labouring class in such a case are in a miserable plight indeed. The small-farm system, and still more the small-estate system, may possibly be defensible on other grounds of state policy, but for its power to turn the soil to the most useful account; and for its power, or rather want of power, to "stock" the country with an intelligent middle-class population, it admits of no defence. Mr. Howard's excellent paper is indeed a sufficiently convincing proof that English agriculture, in spite of our higher northern latitude, is on the whole more productive than that of such districts as he had visited; and that taking even Belgian farming with which to compare it, and with which it has been occasionally contrasted to its discredit, the agriculture of our country is on the whole superior, whether as to its produce of grain and of meat or as to its maintenance of an intelligent and well-conditioned tenantry.—The condition of the English agricultural labourer has lately occupied the attention of several Farmers' Clubs, and it seems proved that the mere labourer in the country is on the

whole better off than the mere labourer in town. The summary of the 'Agricultural Gazette' on the subject may be adopted as on the whole trustworthy:—

"Probably the safest conclusion at which an outsider, patiently considering the various allegations, can arrive, may be stated thus:—Both in country and in town great poverty and great misery exist; both in country and in town the provident and well-conducted man is able to rise in his position; whether in country or in town, there is no help, even for the 'helpless' classes, that can approach *self-help* for its power and efficiency. In the worst-paid agricultural districts the young unmarried agricultural labourer has plenty of pocket-money. He can squander it and acquire habits which will render comfort in after-life impossible, whatever be his earnings; or he can save it, and begin life with a good character, a houseful of furniture of his own, and the best girl in the parish for his wife.

"The possibilities of the agricultural labourer, whether for decent comfort or for utter misery, are at least equal to those of the corresponding class in town. And we feel sure that any considerate master who by the interest which he takes in the lads and young men upon his farm, shall retain them in his service, and thus keep them from the chances of town life, will at least have done them no harm. Paying them as much as possible according to their work, *i.e.* 'by the piece,' and interfering successfully by friendly advice in the alternative before them of saving or of wasting wages in their youth, he will have secured for them a place in the higher division of a class which contains a large proportion of individuals living in comfort and respectability."

The beet-sugar manufacture is prospering. Mr. Duncan's factory at Lavenham is answering his purpose, and it is also answering the purpose of the growers of sugar beet in that neighbourhood, so that in all probability we have at length secured the establishment among us of a new industry, from which, judging by its effect in agricultural districts of France and Germany, the best consequences may be anticipated.—The results of the application of sewage manure to land have been reported at Lodge Farm, near Barking, and elsewhere, as having been this year satisfactory. It is impossible to doubt that this subject will soon rank with the very foremost in agricultural and social importance.

2. ARCHÆOLOGY (PRE-HISTORIC),

And Notices of Recent Archæological Works.

IN vol. v. (No. xx.), p. 546, Oct. 1868, we gave a short account of the meeting of the International Congress of Pre-historic Archæology at Norwich. The papers read at that meeting have since been published, and now form a handsome volume, well illustrated by fifty-three plates and numerous woodcuts.* It would be difficult to estimate the relative value of the contents of this volume, but one paper which, to us, appears a singularly important communication is by Mr. George Busk, "On the Caves of Gibraltar in which Human Remains and Works of Art have been found." This contribution, which is illustrated by twelve plates, maps, and plans, contains the most complete record yet published of those interesting limestone caves and fissures for which the Rock of Gibraltar is celebrated, but which, till lately, only served to gratify curiosity, or, by their illumination, to eke out the scanty amusements of an almost isolated garrison.

It was to the investigation of these caverns that the last efforts of the late Dr. Hugh Falconer's life were directed, in conjunction with Mr. Busk, the work being carried out upon the spot by Captain Frederic Brome, late governor of the military prison at Gibraltar, whose unwearied labours during the last five or six years have been devoted to their exploration.

The rocky peninsula of Gibraltar is a detached promontory, composed principally of limestone, about three miles long and three-quarters of a mile in its greatest width, and lies nearly due north and south. The lower portion of the western side spreads out so as to form an irregular sloping surface, here and there interrupted by longitudinal cliffs and ravines; upon the gentle declivities of which the principal part of the town of Gibraltar is built.

The eastern face, on the contrary, is a nearly perpendicular escarpment of limestone rock rising up at 'Wolf's Crag,' or 'North Front,' in a cliff 1250 feet high; at the 'Signal Station,' or 'Middle Hill,' 1255 feet; and at 'Sugar-loaf Hill,' on which O'Hara's Tower stands, it rises to a height of 1408 feet above the sea. A broad plain extends beneath 'Sugar-loaf Hill' to the south, called 'Windmill Hill Flats,' whilst at a still lower level 'Europa Flats' form the southern termination of the promontory. The mass of the rock consists of a Secondary Limestone of Jurassic age,

* 'International Congress of Pre-historic Archæology: Transactions of the Third Session, opened at Norwich, 20th August, and closed in London, 28th August, 1868.' London: Longmans, Green, & Co. 1869. 8vo. Pp. 419. Illustrated with numerous plates and woodcuts.

much fissured and dislocated, and dipping to the west, but towards the southern extremity the beds become nearly vertical.

As is well known, *caves* constitute a prevailing feature of limestone rocks in all parts of the world, and in no place are they more numerous within a similar compass than in the promontory of Gibraltar, which has, in fact, on that account sometimes been termed the 'Hill of Caves.'

The caves are of two kinds. 1. *Littoral or sea-caves*, scooped out horizontally by the waves at the sea-level; of which kind there are numerous instances all along the base of the eastern face; successive terraces, one above another, are also visible on the same face, each furnished with its line of sea-caves, exactly like those at present at the level of the water. It would seem, however, that most, if not all, of these caves owe their origin to their being situated in the line of a fissure or fracture of the rock of which the sea has taken advantage to begin its scooping action. 2. *Inland caves*, which do not exhibit any appearance of marine erosion, but may be described as ramified and intersecting fissures, descending more or less vertically to great depths, and enlarged by the action of rain-water charged with carbonic acid.

The principal littoral or sea-caves are:—

'Martin's' and 'Fig-tree' caves, 700 feet above the sea, in the eastern face of the rock below O'Hara's Tower; some caves just above the blown sands in Catalan Bay; 'Monkey Cave,' 100 feet above the sea; 'Beefsteak Cave,' in the cliff below Europa plateau; 'Genista Cave,' No. 4, 40 feet below the top of the eastern cliff of Windmill Hill plateau; 'Poca Roca Cave,' in the western face of the northern end of the rock; besides many smaller caves in the eastern face.

The principal fissure-caves are:—

The famed 'St. Michael's Cave,' opening to the west, situated in the southern portion of the rock, at an elevation of 1100 feet above the sea; the 'Genista Caves,' Nos. 1, 2, and 3, all situated in the Windmill Hill plateau, where there is also a deep ossiferous fissure.

The four Genista Caves, Martin's Cave, St. Michael's Cave, and some others, have yielded evidences of early man, in the form of osseous remains associated with flint knives and flakes, stone axes, polished and chipped; worked bones, serving as skewers, arrowheads, needles, and gouges; anklets or armlets of shell, hand-made pottery, querns, rubbing-stones, and charcoal. With these were found remains of numerous animals,* including:— *Rhinoceros*

* [Those marked thus §, are abundant; and thus §§, very abundant.] A single molar of *Elephas antiquus* was obtained many years since by the late Mr. James Smith, of Jordan Hill, in an old sea-beach (now demolished) at Europa Point, the southern extremity of the rock.

etruscus, Rh. leptorhinus § (extinct); *Equus, Sus priscus* (extinct); *Sus scrofa, Cervus elaphus*, var. *barbarus* §, *Cervus dama* §, *Bos* (a large form), and *Bos taurus* §. Two forms of Ibex, *Capra Ægoceros* §§; and also the common goat, *Capra hircus; Lepus timidus, Lepus cuniculus* §§, *Mus rattus.* Of the carnivora were determined *Felis leopardus, Felis pardina, Felis serval, Hyæna brunnea, Canis vulpes, Ursus* sp. Remains of the common dolphin, numerous genera and species of birds, a species of tortoise, and numerous remains of fishes, of which the tunny is most prominent.

The remains are imbedded in red cave-earth, and also in a black layer similar to that noticed in the caves of France and elsewhere. In many instances the organic remains have been carried down from one cavern to another at a lower level through long fissures, by the heavy autumnal floods which pour from the higher grounds down upon Windmill Hill plateau (where many of these ossiferous caves are situated), bringing with them the remains of the various animals which at an earlier period inhabited the thickly-wooded heights, now entirely destitute of trees and only covered at places by the little *Chamærops humilis.*

Many human and animal remains attributable to modern periods have been also met with; but the older human remains are distinguished by peculiarities in the thigh-bones, which closely resemble those met with in the Cro-Magnon Cave.*

Mr. Boyd Dawkins gives a *résumé* of what is known on the subject of 'The Antiquity of the Iron Mines of the Weald.'† In the middle of the Wealden formation are two thin bands of ironstone, from which all the iron was obtained. The mines are scattered throughout the district: the method was to sink a shaft through the superincumbent clay to the ironstone, and remove as much ore as was within reach; then fill up and sink again a little farther on, so that the shafts lie very close together. They vary in depth from about 7 or 8 to 40 feet, and in diameter from 3 to 6 feet. The first historical notice is in a grant of Henry III. to the town of Lewes; but Samian and other Roman ware, bronze fibulæ, coins of Nero, Vespasian, &c., having been found at several localities scattered amongst the scoriæ at depths varying from 2 to 10 feet, tend to show that they were worked during the Roman period. These Roman remains were associated with flint flakes and rude unturned pottery identical with that termed Keltic, in some places, and in others alone, which, together with the passage in Cæsar's 'Commentaries' describing the inhabitants of the maritime part of Britain, "utuntur aut ære aut taleis ferreis ad certum

* See our Chronicle of Archæology for July last, p. 411.

† Mr. Boyd Dawkins made careful notes of these workings during his stay in the district whilst engaged on the Geological Survey of the Wealden; and he also refers to Mr. Lower's papers in the 'Sussex Archæologia.'

pondus examinatis pro nummo. Nascitur ibi . . . . in maritimis ferrum; sed ejus exigua est copia," make Mr. Boyd Dawkins believe that these workings were commenced long previous to the Roman occupation.

Numerous similar pre-historic iron-mines worked upon the same primitive plan (the product of which, like that of the Fan tribes in Africa at the present day, could only have amounted to a few pounds' weight of metal) are to be met with in many places along the northern part of Norfolk, a little inland, from Cromer to Hunstanton.

The Département de L'Aveyron, to which we referred in our last Chronicle as that in which the Cavern of Bruniquel was situated, seems to be equally rich in megalithic monuments as it undoubtedly is in caves. Of these Dolmens numerous illustrations are given, and also of the ornaments and implements of stone, bone, and bronze found within the mounds and circles.

The Memoir by the Rev. Richard Kirwan, M.A., on the excavation of three Tumuli on Broad Down, Farway, near Honiton, Devon, is of the highest archæological interest, not only on account of the works of art which they contained but also as exhibiting three barrows, each differently constructed, belonging to a very early period, probably long antecedent to the Roman occupation of Britain. Mr. Kirwan's paper is illustrated by nine plates.

There are many other papers in this volume, but we have not space to notice them here.

'Transactions of the Devonshire Association for the Advancement of Science, Literature, and Art, 1869.' 8vo. Pp. 310.—Mr. Pengelly has now published the second part of his 'Literature of Kent's Cavern,' in which he gives the whole of the Rev. J. Mac Enery's manuscript. 'On the alleged occurrence of *Hippopotamus major* and *Machairodus latidens* in Kent's Cavern, Torquay.' The author, in revising the evidence, comes to the conclusion that no remains belonging to the former animal have been found, but that the latter undoubtedly has.

Mr. G. Wareing Ormerod gives a notice of the molars of *Hippopotamus major* stated to have been found in Kent's Cavern, and, like Mr. Pengelly, does not think there is any trustworthy evidence that they were found there.

Mr. Pengelly also contributes a few notes upon the submerged forest at Blackpool, near Dartmouth. This forest, usually entirely concealed by the sand thrown up by the waves, was, for the third time during this century, exposed to view by the tempestuous weather in February last. In the seaward portion was a brownish

drab-coloured clay, becoming bluish higher up, thickly covered with vegetable *débris*, trunks of trees varying from 6 inches to 2 feet in diameter, branches, twigs, leaves, and hazel-nuts; no animal or human remains or tools were found, though some of the hazel-nuts, which were very abundant, had been gnawed (by squirrels?). Many stumps were still in a vertical position. The movement of submergence must have been uniform, as it had not disturbed the approximate horizontality of the old forest ground, and must have amounted at the least to 18 feet, the greatest tidal range on that part of the coast, but there are no data from which to calculate how much greater it may have been.

3. ASTRONOMY.

(Including the Proceedings of the Astronomical Society.)

THE careful examination of the photographs of the recent total solar eclipse in America has revealed a very interesting fact respecting the sun's corona. It has long been questioned whether this appearance belongs to the sun or is merely an optical effect due to our own atmosphere. It appears from the careful comparison of the photographs taken during the progress of the last eclipse, that the moon *passed over* the corona. The reader will remember that it was from observations of this sort, made nine years ago, that astronomers were led to the conclusion, now incontrovertibly established, that the prominences belong to the sun. There seems little reason for doubting that we may now come to the same conclusion respecting the corona.

It must be mentioned, however, that many eminent physicists and astronomers are still disposed to question the justice of this conclusion. Passing over the observations made by Mr. Pickering during the total eclipse, from which he is inclined to think that the corona belongs to the moon, we may dwell on sounder reasons which have been alleged against the belief that the corona belongs to the sun. Recent observations of the spectra of the prominences by Mr. Lockyer and other astronomers, compared with the careful study by Dr. Frankland of the corresponding spectra of terrestrial elements under varying circumstances of pressure and temperature, have led to the belief that the part of the sun's atmosphere which lies above his photosphere is not very dense,—certainly not by any means so dense as it would be if the corona were in reality a solar atmosphere.

On the other hand, Professor Young, an American astronomer, has made a highly significant observation. He has found that the spectrum of the corona exhibits the same bright lines as the auroral

spectrum. Professor Harkness also found that the corona gives a bright-line spectrum, but superposed on a continuous one. Now when we combine Professor Young's observation with Ängstrom's discovery that the Zodiacal Light gives the same spectrum as the Aurora, it becomes one of the most interesting, and at the same time one of the most perplexing, ever made by astronomers. A bright-line spectrum indicates gaseity, and we cannot believe the corona to be a gaseous solar envelope, nor indeed to be gaseous at all, if we accept Lockyer's observations. Nor can one understand the Zodiacal Light to be gaseous.

Perhaps, however, all these observations may be reconciled by regarding the spectrum of the corona to be not necessarily indicative of the gaseity of this object in its entirety. Electrical discharges taking place between the particles (probably solid) of which the Corona and the Zodiacal Light consist would give a spectrum of bright lines. Then also we could understand the continuous spectrum seen by Professor Harkness, since the bodies forming the corona would reflect the solar light.

The whole subject is, however, at present full of difficulty and perplexity. In future eclipses the corona will doubtless attract a large share of the observer's attention.

Another result of the American eclipse observations has been the suggestion by Professor Young of a new mode of observing the coming transit of Venus. It was found that the approach of the moon to the sun's limb was cognizable before the moment of actual contact, owing to the gradual obliteration of the bright lines belonging to the spectrum of the chromosphere; and Professor Young suggests that the approach of Venus might be observable in the same way in 1874 and 1882. There are, however, many difficulties in the application of this method. In particular the method applies to external contacts, and the preparations hitherto made have had reference to internal contacts. At some of the best places for observing internal contacts, external contacts will not be observable at all. Then astronomers are not quite certain at what part of the sun's limb contact will take place, nor at what angle Venus will cross the limb. These circumstances would leave the spectroscopist small chance of success in an observation of so delicate a nature.

It remains to be seen, however, whether spectroscopic observation may not be applicable in other ways. For example, Mr. Huggins has suggested that instead of the slit being placed at right angles to the sun's limb, it should be placed tangentially. Mr. Proctor has recommended an open slit, placed tangentially so as to include the solar cusps before internal contact. These cusps would give two continuous spectra, the approach of which towards each other would indicate the moment of internal contact more exactly than the approach of the cusps.

The discovery of a small comet by the indefatigable Tempel has to be recorded. No observations of special interest have been made upon this object, however.

The November meteors have not been very conspicuous in Europe, this year. Unless we hear of star-showers in America, we must conclude that the denser part of the meteor-stream has now passed completely away from the neighbourhood of the earth's orbit. In that case we need not look for any remarkable display of the November meteors for some twenty-eight years or so.

Zöllner, the eminent photometrician and astronomer, has devised a new form of spectroscope for observing the stellar motions of recess and approach. The plan may be briefly described as follows:—The line of light which is to be analyzed by the spectrum is in the focus of a lens for parallel rays. These parallel rays are divided into two portions, each passing through two systems of direct-vision prisms, placed one below the other, and with their refracting edges turned in opposite directions. It is clear that by this arrangement two spectra are formed, the red end of one opposite the blue end of the other, and *vice versâ*. These spectra are observed together by means of a small telescope, the object-glass of which is divided into two adjustable parts by a line parallel to the length of the two spectra. It is thus possible to bring any line of one spectrum into coincidence with any line of the other, or even partially to superpose two lines. Now it is clear that if a celestial object is moving from or towards us at such a rate as to produce an appreciable effect on the position of a given bright line, Zöllner's arrangement will exactly double the effect. This, however, is not the chief advantage of the arrangement. In fact this is, in reality, no advantage at all (though Zöllner appears to think differently), for it is obtained by an arrangement which halves the light of the spectrum; and by simply doubling the dispersive power the same increase of effect could be obtained at exactly the same cost. The great advantage promised by the new arrangement is this, that there will be no occasion to compare a line directly with the corresponding line of a terrestrial element. Thus, supposing we wish to determine whether a star is moving from or towards the earth, by observing a particular dark line in its spectrum, we should in the first place adjust the two spectra so that this line seen in one would be brought into coincidence with the same line seen in the other, supposing there were no motion of recess or approach. This can be done with great nicety by observing the corresponding bright line of a terrestrial element. Then the telescope being directed towards the star whose motion is to be determined, there will be found no longer to be coincidence, if the star is in motion either from or towards the eye. By observing how much the micrometer screw by which the divided object-glass is adjusted has to be moved in order to secure coinci-

dence, it becomes possible to estimate the rate of the star's motion. Zöllner believes that the probable error of a single observation will correspond to a motion of less than half-a-mile per second.

There will be an eclipse of the moon, partly visible at Greenwich, on January 17th. The eclipse will begin at noon of that day, and the moon will rise (at Greenwich) slightly eclipsed, and obscured by the penumbra. The last contact with the penumbra will take place at 5 h. 37 m. P.M.

There will be a partial eclipse of the sun, invisible at Greenwich, on January 31st.

Jupiter will remain for some time a conspicuous object in the western skies after sunset. On March 18th Saturn will be in quadrature preceding opposition. Venus will be at her greatest brilliancy as an evening star on January 18th.

PROCEEDINGS OF THE ASTRONOMICAL SOCIETY.

As usual at this season we have but one number of the Monthly Notices—the supplementary number—to report on. It contains but six papers, and four of these are by one author.

Dr. C. Pihl gives a short paper on the subject of the cluster in Perseus, known as 34 Messier, which he has been studying since the year 1860. He indicates certain errors in his former estimates of the declinations of stars in this cluster, these errors resulting from an error in one of the co-efficients employed for reducing the declinations of the stars.

Mr. Proctor supplies a calculation of the comparative clinging of Venus to the solar limb during the transits of 1874 and 1882. From this it appears that the interval between real and apparent internal contacts will vary from 29·41 sec. to 35·11 sec. in 1874, and from 20·46 sec. to 21·39 sec. in 1882. Hence the observed difference of duration, or of absolute time, in 1874 should exceed the corresponding differences in 1882 in the proportion of 1·547 to 1, to have an equivalent value.

He adds a note on the later transit, giving the places where ingress and egress are most accelerated by parallax, as he had already done for the transit of 1874. He remarks that the corrections necessary for the transit of 1882 are much less than those for the transit of 1874, not one of the places now determined differing by much more than 300 miles from the place obtained when phase and parallax are neglected.

The Astronomer Royal supplies a most valuable contribution to science in the form of "A Note on Atmospheric Chromatic Dispersion as affecting Telescopic Observation, and on the Mode of correcting it." Every astronomical observer is familiar with the

annoying indistinctness of objects observed near the horizon. In such observations as will have to be made during the coming transits of Venus, it would be of the utmost importance to get rid of this indistinctness. There would then no longer be any necessity for limiting the stations where observers should be sent to places where the sun would have a considerable elevation above the horizon. And this would be an immense advantage, because at all the stations which would otherwise be the best the sun will be low. Now the Astronomer Royal has shown that by means of a set of flint prisms, of small refracting angle, the observer can get rid in great part of the annoying dispersion we have spoken of. One prism only is used at a time, the prisms of the larger refracting angles being used for an object close to the horizon. The following reports by Mr. Carpenter (of the Greenwich Observatory) establish in the most satisfactory manner the value of the new method.

1869, July 15, 11 h. 50 m. to 12 h. 20 m. Saturn, zenith-distance about 82°, viewed with the great equatorial power 245. Atmospheric disturbances very bad:—Prism 12° corrected the dispersion perfectly; prism 8° corrected it fairly; prism 6° corrected it partially; prisms of smaller angle had no effect.

1869, July 21, 9 h. The moon, zenith-distance about 78°, viewed with the altazimuth, power about 100. Prism 2° slightly diminished the colour; prism 4° better than the last; prism 6° destroyed the colour entirely. The definition of the details about the moon's ragged edge very much improved. Prisms of larger angle gave an opposite dispersion.

This plan is obviously as satisfactory as it is simple. It cannot but be regarded as of extreme value and importance; and, simple as it is, will take high rank among the many important improvements which the Astronomer Royal has effected in the science of Observational Astronomy.

Mr. Proctor puts forward, in a paper "On the Distribution of the Nebulæ," illustrated by four folio engravings, a new theory respecting the constitution of the universe. He expresses his belief that the nebulæ are not external galaxies, but that all their varieties are included within the sidereal system. In another paper he indicates a method for measuring the discs of those stars which are liable to be occulted by the moon. This method consists in causing the image of a star to rotate rapidly in a circle, which is itself rotated, but less swiftly. Thus the image of a star follows an epicycloidal path, many coils of which will be visible simultaneously, owing to the persistence of luminous impressions. When the moon occults a star (a process which in reality occupies but a small fraction of a second) the coils will vanish, but according to the greater or less duration of the occultation a larger or smaller

arc of the coil last formed will exhibit a gradual fading-off of light towards its extremity. Mr. Proctor has calculated that a star ten times as far off as *a* Centauri, and having a real diameter as large as our sun's, would give an arc of fading light about 56 degrees in length.

4. BOTANY.

Edible Fungi.—During the last few years great attention has been paid by botanists on the one hand, and epicures on the other, to the edible qualities of certain fungi. Notwithstanding the prejudice generally entertained against this class of vegetable productions, extending in Scotland, Wales, and some parts of England even to the common mushroom, there is no question that a considerable number of species, very abundant in this country, are not only wholesome, but delicious articles of diet, and are at least as easily distinguished, with a little practice, from the poisonous or suspicious species, as berries or other wild fruits. Containing a larger proportion of nitrogen than any other family of the vegetable kingdom, they furnish an abundant supply of nourishment at a period of the year when very little else is to be obtained. It is calculated that there is scarcely a parish in England where tons of wholesome food are not allowed to waste every year, to say nothing of the facilities for their artificial culture. Mr. Berkeley reckons that there are at least 30 distinct English edible fungi; Dr. Curtis has partaken of 40 in North Carolina, and enumerates 111 species in that state alone reputed to be edible. Fries, the greatest living cryptogamist, is publishing a large work on the edible and poisonous fungi of Sweden; several works of a similar character have recently been brought out in Italy; in our own country the Rev. M. J. Berkeley, Mr. Worthington G. Smith, and Dr. Bull of Hereford, may be mentioned as having paid special attention to the subject. In addition to the mushroom *Agaricus campestris* and the truffle *Tuber æstivum*, the following species are wholesome, pleasant to the taste when cooked, easily distinguished from all other species, and more or less abundant in different parts of the country:—*Agaricus arvensis*, or the horse-mushroom; *A. procerus*, the parasol-mushroom; *A. ostreatus*, the vegetable oyster, growing on the trunks of trees; *A. melleus*, abundant on dead stumps; *A. orcella*, the vegetable sweet-bread; *A. prunulus*, the plum-mushroom; *Morchella esculenta*, the morel; *Hydnum repandum*, the hedge-hog; *Fistulina hepatica*, the vegetable beef-steak, on the stumps of hollow trees; *Coprinus comatus*, very common in gardens; *Marasmius oreades*, the fairy-ring champignon; *Boletus edulis*, in woods; and *Lycoperdon giganteum*, the giant puff-ball, when in the young state.

Many of these species are favourite articles of food in the autumn and winter with the peasantry in various parts of the Continent, and are everywhere sold in the markets. Our common mushroom is among the kinds forbidden by the police regulations to be sold in Rome, but is to be met with in the markets of Palermo and Messina.

Acclimatization of Half-hardy Plants.—Great efforts have recently been made in France to naturalize trees and shrubs—natives of warmer climates; and these have been attended with considerable success in some instances. The Bamboo, introduced at Tours, Macon, and Angers, has succeeded admirably, and has withstood a very considerable degree of frost. It seems likely to flourish even in the climate of Paris, where it is grown in the gardens of the *Société d'Acclimatation.* Several species of *Eucalyptus*, especially the *E. globulus*, have also been planted extensively in the Department of the Var, where they have been found to resist the destructive northwest wind known as the *mistral.*

The Fertilization of Winter-flowering Plants.—Mr. A. W. Bennett contributes to the first number of the new scientific magazine, 'Nature,' the results of some observations on the fertilization of those plants which habitually flower in the winter, when there are few or no insects to assist in the distribution of the pollen. He finds that in those wild plants which flower and produce seed-bearing capsules throughout the year, as the white and red dead-nettles, shepherd's purse, chickweed, groundsel, &c., the pollen is uniformly discharged in the bud before the flower opens. Many garden-plants, on the other hand, natives of warmer countries, but which still flower with us in the depth of winter, never bear fruit in this climate, and in them the pollen is not discharged till the flower is fully open. Of this class are the yellow jasmine and the *Cheimonanthus fragrans*, or all-spice tree; in the latter species the arrangement of the pistil and the stamens is such as to render self-fertilization impossible.

Leonardo da Vinci as a Botanist.—In the recently commenced 'Nuovo Giornale botanico Italiano,' published at Florence, Signor Uzielli has an interesting article on some botanical observations of Leonardo da Vinci, showing that to the great painter is due the credit of the first observation of certain points in the structure of plants, which has been generally attributed to writers of a considerably later date. The constancy of a uniform arrangement of the leaves on the branches in the same species, known as the Law of Phyllotaxis, is stated in botanical works to have been first observed by Grew and Malpighi towards the close of the seventeenth century. Da Vinci, however, who lived from 1452 to 1519, records observations to the same effect, though not so accurate, in his great 'Treatise on Painting.' To the same two botanists is also ascribed the discovery of the mode in which the stems of exogenous trees

increase beneath the bark by the formation of concentric rings of wood, from the number of which the age of the tree can be determined. This had, however, also been already observed by Da Vinci, and is recorded in passages in the same work.

Arctic Flora.—Dr. Berthold Seemann discusses in the 'Journal of Botany' the question whether vegetation extends to the North Pole, supposing land exists there. He answers the question in the affirmative, maintaining that excessive cold in winter exercises but a limited influence upon a vegetation which, like the Arctic, enjoys the protection of a thick covering of snow, and is besides in a state of inactivity. The temperature of the summer during the months of July and August has by far the greatest share in the distribution of vegetable life in the northern regions; and the lowest temperature during those months is not found in the most northerly point yet reached by any exploring expedition, but in Winter Island on the eastern shores of the Melville Peninsula, where the mean temperature during July and August ranges between 34° and 36° F. That spot, which may be called the phytological pole, is nevertheless covered with vegetation; and, knowing as we do, that plants do grow not only on a frozen soil, but even, as in Kotzebue Sound, on the tops of icebergs, there is no reason to suppose that the terrestrial pole is destitute of vegetation. The most northerly berry-bearing plant yet recorded is *Vaccinium Vitis-Idæa*, or the cranberry, gathered in Bushman Island, on the north-west shore of Greenland, by Captain W. Penny, or in latitude 76° N., longitude 66° W. The most northerly berry-bearing genera are *Vaccinium*, *Oxycoccus*, *Rubus*, *Cornus*, and *Empetrum*. It is stated that occasionally berries ripen in Lapland.

Vegetation of Howe's Island.—The flora of this island, 300 miles from Sydney and 500 from Norfolk Island, has been investigated by Mr. Charles Moore, and is found to resemble much more closely that of the latter island than of Australia. Its situation is 31° 36′ S. lat., 159° 5′ E. long.; it is 4½ miles in length and 1¼ in breadth, possesses two mountains about 2500 feet high, and is entirely covered with vegetation, with no barren spots except the coast and the precipitous cliffs. The indigenous species are very few, most of them being peculiar to the island and undescribed. Of Endogens there are four species of Palm, all undescribed and of great value to the natives; two species of *Pandanus*; three Grasses; two Orchids; a *Juncus*; a *Smilax*; one species belonging to *Iridaceæ*, one to *Amaryllidaceæ*, three to *Cyperaceæ*, and one to *Commelynaceæ*. All the clearings are, however, covered with introduced European plants, including the couch-grass. Among Exogens, the Australian *Proteaceæ* and *Leguminosæ* are entirely wanting; *Epacridæ* and *Myrtaceæ*, so abundant in Australia, are represented, the former by a single species, a tree 30 or 40 feet in height, grow-

ing at great elevations; the latter by two, the leaves of one of which are used by the natives in the place of tea; a very remarkable undescribed *Ficus* forms a considerable portion of the larger vegetation, growing sometimes 100 yards across, with very numerous root-stems. The castor-oil plant and *Solanum laciniatum* are among the most troublesome introduced weeds. Ferns are very abundant, but of non-Australian types; the genera *Adiantum* and *Aspidium*, so abundant in Australia, New Zealand, and Norfolk Island, were not observed.

The Lichens of Greenland.—Dr. Lauder Lindsay has worked out with great care, in an article read before the Botanical Society of Edinburgh, an account of all that is at present known respecting the Lichens of Greenland. While in 1840 only 59 species had been recorded, Dr. Lindsay is now able to enumerate 268 as natives of Greenland, and thinks that this number may probably be raised to 300. The degrees of latitude within which they have been collected range from 60° to 75°, the majority having come from about 70°, a few from as far north as 82°. The almost entire absence of arboreal vegetation in Greenland necessarily affects the character of the Lichen-flora, very few corticole and foliaceous species being found, but a great preponderance of the saxicole forms. One prominent feature is the great abundance of the sombre-coloured *Umbilicariæ*, giving in many parts a funereal colouring to the landscape. Deducting the species that are mainly or entirely confined in their distribution either to Greenland or to Arctic countries, the majority at least of the remainder occur on the Scandinavian Alps, and many of them on the Alps of Scotland and Switzerland, or generally on those of continental Europe; while a considerable number are common British forms. The lichen-flora of Greenland differs, on the other hand, very considerably from that of Arctic America. The lichens of Spitzbergen and its islets are as numerous as those of Greenland, notwithstanding the smaller area; while the whole list of Melville Island lichens contains only twelve species. There is no record of any species of lichen being turned by the Greenlanders to any economic purpose, notwithstanding the abundance of *Cladonia rangiferina*, or the "Reindeer-moss," and of other species which, in other Arctic countries, have been serviceable in supplying the wants of man or animals.

Hibernation of Duck-weed.—It has long been known that some species of *Lemna*, or duck-weed, produce, at the approach of winter, leaves of a different character to those formed in the spring, which fall to the bottom of the pond or stream, enabling the plant to live through the winter. A series of more accurate observations on this point is recorded by M. Van Horen in the 'Bulletin de la Société Royale de Botanique de Belgique.' The species of *Lemna* indigenous to Belgium are the same as those found in this country; of these

M. Van Horen finds that two only, the *L. polyrrhiza* and *gibba*, produce leaves of a different form in winter; while with the three other species, *L. minor*, *trisulca*, and *arrhiza*, the ordinary leaves live through the winter, remaining on the surface. In *L. polyrrhiza* these winter-leaves first make their appearance in August or September. They are much smaller than the ordinary leaves, reniform or sometimes elliptical, olive-brown on both sides, and not gibbous beneath; their roots are exceedingly minute, and at first hidden within the leaf. The aëriferous cells which serve to support the ordinary leaves on the surface do not exist, causing the winter-leaves to resemble an undeveloped bud. In consequence of the absence of these vessels they are heavier than the water, and fall to the bottom as soon as any agitation of the water detaches them from the parent-leaf, which perishes with the first frost. At the ordinary period of the revival of vegetation, a small bubble of oxygen appears on the upper surface of these submerged leaves, which carries them to the surface, from which they again descend should the temperature fall below a certain point. In *Lemna gibba*, leaves of a similar character, were observed hibernating beneath the water, differing in shape, size, and structure from those developed during the summer.

Evaporation of Water and Decomposition of Carbonic Acid by Plants.—An interesting and important series of experiments has been made by M. P. P. Dehérain, of Paris, for the purpose of determining the natural agents most efficacious in promoting the physiological functions of the leaves of plants, the evaporation of water, and the decomposition of carbonic acid. The results arrived at are as follows:—1. These two processes are carried on simultaneously and with corresponding intensity, the same agents which facilitate the one being operative also with the other. They proceed more rapidly from the upper smooth and hard surface of the leaves than from the under-surface. 2. The principal agent in determining these changes is not temperature, but light. While the amount of water given off was hardly affected by any changes of temperature, proceeding almost with equal rapidity even when surrounded by ice; in bright sunshine leaves were found to give off, in long exposure, more than their own weight of water, while in diffused light it amounted to only six to eighteen per cent., and in total darkness was scarcely perceptible. The evaporation and condensation of water proceeded with equal rapidity when the air was perfectly saturated with moisture. 3. The different rays of light are not equally efficacious in promoting these actions. M. Dehérain found, as the result of a number of experiments, that, with an equal intensity of light, the red and yellow rays, which have little photographic power, cause in the same time the decomposition of about five times as much carbonic acid, and the evaporation

of a corresponding amount of water, as compared with the action of the blue or violet rays, which are the most active in decomposing chloride of silver.

Viridescence of Leaves.—M. Prillieux has, on the other hand, shown, by a series of experiments on barley, that the production of the green colouring matter of leaves proceeds more rapidly in diffused light than in the direct light of the sun, in opposition to the production of oxygen, which is the more abundant the stronger the light.

Peloria in Labiatæ.—M. J. Peyritsch has presented to the Academy of Sciences at Vienna some remarkable instances of "Peloria," that is, of abnormal regularity in flowers usually irregular, observed in the order *Labiatæ.* They occur in *Stachys sylvatica,* the common woundwort; *Betonica officinalis,* the common betony; and in seventy individuals of *Galeobdolon luteum,* the yellow dead-nettle. In the latter instance the flowers are formed by the increase of two segments of the calyx, and by an alteration in the form of the divisions of the upper lip of the corolla, so that they become similar to the lateral lobes of the lower lip. The stamens are perfectly normal, and bear well-developed pollen; but the carpels are abortive.

The Leaves of Conifers.—At the meeting of the American Association for the Advancement of Science, held at Chicago, Mr. Thos. Meehan read a paper on the leaves of *Coniferæ.* He pointed out that the true leaves of *Pinus* consist of bud-scales; and what are popularly known as the leaves are in reality arrested phylloid shoots. The chief portion of the true leaves in most plants belonging to this order is adnate to the stem; sometimes they have the power of developing only into scale-points; sometimes into foliose tips. In *Larix* the true leaves are linear, spathulate, entirely adnate to the stem. There are two kinds of stem-growth. In one case the axis elongates and forms shoots; in the other, axile development is arrested and spurs are formed. On the elongated shoots the leaves are scattered; on the spurs they are arranged in whorls. There are therefore in the larch two forms of leaves: the one free, the other adnate. In *Cryptomeria* the true leaves adhere for four-fifths of their length on vigorous shoots; in *Juniperus,* for nearly their whole length on vigorous shoots; while on weaker branches they are almost entirely free. In *Pinus* the phylloid shoots are situated in the axils of the true leaves. Mr. Meehan sums up his observations as follows:—The true leaves of *Coniferæ* are usually adnate to the branches. Adnation is in proportion to the vigour of the genus or species; or of the individuals in the same species; or of the branches in the same individual. Many so-called distinct species of *Coniferæ* are probably only varieties of the same species in various states of adnation.

Scorching of Leaves by the Wind.—M. Marchand, engineer of Fécamp, in Normandy, has made some observations on the effect produced on the leaves of various trees by the violent storm of the 12th to the 16th of November. The wind was from the north-west; and on that side the leaves of nearly all the trees growing near the coast, except the bay, ivy, and tree-mallow, were scorched as if by fire, and lost about 39 per cent. of their normal weight; and were found to have absorbed an appreciable amount of sea-salt, which no doubt obstructed the circulation of the sap and caused them to shrivel up. The leaves exposed to the south-east were not similarly affected.

Japanese Sea-weeds.—At a recent meeting of the Royal Academy of Amsterdam, a collection was exhibited to illustrate the care taken by the Japanese in applying to beneficial purposes the natural products of their country. The collection consisted of sixteen species of *Algæ* which are useful for food or other purposes, together with fabrics manufactured from some of them. Several of the species were altogether new; in other instances the application was entirely novel.

5. CHEMISTRY.

Mr. J. Alfred Wanklyn has made known a very unexpected fact. He says that when chlorine gas is passed over metallic sodium—even when the metal is fused, and whilst in a state of fusion, shaken in contact with the gas so as to expose fresh metallic surface—there is no increase in weight, and of course no action.

The increasing demand for albumen, especially for the use of calico-printing, has at various times led to attempts to obtain a supply of this article from the blood of slaughtered oxen and sheep. M. Dolfus-Galline describes a process invented by him, and actually in operation on a large scale at the *abattoirs* of Dornach, France. The process is based upon the fact of the coagulation of the cruorine of the blood, and its separation from the serum, the latter yielding, by cautious management, a dried albumen, which can be applied instead of egg albumen for clear and bright colours. Ten litres of serum yield 1 kilo. of dry colourless albumen; the blood of two and a half oxen, ten sheep, or seventeen calves, produces the same quantity of dry albumen, *viz.* 1 kilo.

Referring to Professor Graham's researches on the occlusion of hydrogen by palladium, M. Favre states, that according to his experiments the hydrogen in palladium saturated therewith is present as a chemical compound, and not simply in the state of

condensed gas. He also states that the vapour of boiling mercury is as little a conductor of electricity as hydrogen is, and that therefore the non-conductibility of hydrogen for electricity cannot be regarded as an objection to its being a metal.

M. Chevrier has studied the action of vapour of sulphur on various gases. With oxygen it forms a slightly explosive mixture under some conditions; but usually the vapour of sulphur burns off quietly. With hydrogen it yields sulphuretted hydrogen gas very abundantly. With nitrogen the author found no action. With proto- and bin-oxide of nitrogen it forms sulphurous acid; nitrogen is set free, and if a frigorific mixture be applied to the apparatus containing the mixed gases and vapours, large so-called lead-chamber crystals are obtained. Oxide of carbon yields, with vapour of sulphur, oxysulphide of carbon.

When sodium is thrown upon water, the hydrogen does not kindle, as is well known, unless the water be warmed, or the metal confined to one spot by blotting-paper. Mr. T. Bloxam, lecturer on Chemical and Natural Philosophy, Cheltenham College, has, however, found that if sodium be dropped upon nitric acid of specific gravity 1·36 (ordinary commercial), the hydrogen burns with ease; but if the acid be diluted, this result ceases. The hydrogen ceases to kindle when the acid is diluted to specific gravity 1·056. The residue contains a fair amount of ammonia.

Dr. Emmerling has been carrying on experiments on the action of water on glass and porcelain. The leading features of his results are the following:—The action of boiling liquids upon glass vessels is proportionate to the duration of time of boiling; it is proportionate to the surface which is in contact with the boiling fluid; it is independent of the quantity of fluid which evaporates during a given time; it decreases with the decrease of temperature of the solution; alkalies, even in dilute solutions, attack glass very strongly; acids, excepting sulphuric acid, generally act less than pure water. Among the salts, those act most energetically whose acids produce insoluble salts with lime, *e.g.* sulphate and phosphate of soda, carbonate of soda, and oxalate of ammonia, the action of each of which increases with the degree of concentration of the solution; those salts which form in water, readily soluble lime-salts, act less strongly than pure water alone, and with the greater degree of concentration of these salts the action decreases; Bohemian glass stands acids better than glass containing soda; Berlin porcelain is only perceptibly acted upon by alkalies.

Dr. H. Schwartz has observed that when the pulverulent metallic zinc which is deposited in the tubes of the Belgian zinc smelting-furnaces is mixed with amorphous phosphorus in powder, and this mixture is gently heated in a hard glass combustion-tube,

while at the same time a current of dry hydrogen gas is passed through, phosphide of zinc is formed. From the phosphide of zinc so obtained, phosphuretted hydrogen may be readily prepared by means of dilute sulphuric acid, or by boiling with caustic potash.

A method of strengthening and rendering woven tissues impermeable to water has been invented by M. Newman. A sulphuric acid bath is made containing acid of about 1·6 specific gravity, and kept at a temperature of 57°. The woven tissues, cotton or linen, are rapidly passed through this bath, being only left in contact with the acid for from ten seconds to two minutes, according to the nature of the tissue, which is immediately after passed through very cold water, and next submitted to a thorough washing process. The effect of the action of the acid is the formation of a varnish-like matter, which, especially after it has been regularly spread over the fabric and incorporated therewith by hot-pressing and calendering, greatly increases the strength of the fabric, and renders it simultaneously impervious to water.

The manufacture of oxygen gas on a commercial scale is increasing in Paris; Mr. Fowler, who has described one of the factories, says that 500 pounds of manganate of soda, furnish 2½ cubic yards of oxygen every hour. This charge is placed in a retort and superheated, steam passed over it; in five minutes all the oxygen is extracted from this quantity of the salt. Hot air passed over this residue for five more minutes restores all the oxygen given up, and the result of an hour's continuous work, or six extractions of oxygen and six re-oxidations, is 2½ cubic yards of oxygen. This oxygen, when it issues from the gasometers, contains about 15 per cent. of nitrogen, but by letting the first portions escape, the quantity of this mixture can be reduced to 2½ per cent. M. Tessie du Mothay affirms that one ton of manganate of soda will yield 100 cubic yards of oxygen daily, or more than 36,000 per year; and this without having to renew the salt once.

According to M. Kessler, when burning magnesium wire is placed in a vessel containing carbonic acid, the latter is decomposed, and carbon deposited. Some nitric acid should be poured into the vessel at the end of the reaction in order to dissolve the magnesia resulting from the combustion, and to make the deposit of carbon distinct. Water having been poured in a rather wide-mouthed flask, it is made to boil as briskly as possible; when, after this boiling has been continued for some time, previously-ignited magnesium wire is held deep down in the mouth of the flask, it continues to burn. The same metal burns with great brilliancy in nitrous and nitric oxide, also in sulphuretted hydrogen and sulphurous acid, but is extinguished by carbonic oxide.

Dr. Poselger deserves the thanks of the public for his determin-

ing, by positive experiments, that the death of fine trees growing along the streets and promenades of many, especially continental, towns, is not due, as has been too often asserted, to the effects of leakage in gas-mains. From the author's experiments made with trees and shrubs, it is a settled point that no damage can accrue to the trees, nor their growth be interfered with, by any quantity of gas which may escape in the soil and find its way to their roots.

MM. Martius and Mendelssohn-Bartholdy have tried whether it would not be possible to prepare chloral, the new anæsthetic, in large quantities, so that if this substance should become used in pharmacy, it could be easily obtained in a pure state. The hydrate of chloral answers this purpose by far the best: it is a white crystalline mass, endowed with considerable hardness; it dissolves readily in water, and is devoid of any smell of chloride of carbon or hydrochloric acid, while it exhibits its own peculiarly strong smell. The authors have exhibited several pounds weight of chloral, and hope shortly to be able to exhibit the synthesis of chloroform by an easily executed method, and also of trichloracetic acid.

Dr. Calvert states that when hypochlorite of lime and sulphate of ammonia are mixed, nitrogen gas is immediately given off, even without the application of heat. The author observes further, that all nitrogenized animal matters (such as albumen, fibrin, gelatine, silk, feathers, and skin) yield, when mixed with a solution of hypochlorite of lime, especially when heat is applied, a large quantity of nitrogen and carbonic acid.

Dr. C. Winkler, during some experiments on the bleaching of wood-pulp for paper manufacture, has found that neither chlorine, bromine, nor any substances the activity of which is due to oxidation, will answer the purpose, the result always being the production of a decidedly yellow and sometimes even brown tinge. Sulphurous acid does not completely answer the purpose; the destruction of the natural colouring matters by means of fermentation did not lead to any good result.

When the lecture-room of a chemical laboratory is provided with a sufficient supply of water under strong pressure, it is possible to exhibit there an experiment which, owing to a deficient pressure of water in such rooms, has been almost unnoticed. The experiment is the following:—Under an ordinary water-tap, the opening of which has from ·10 to 12 metres diameter, a large-sized porcelain basin is placed, containing from 15 to 20 kilos. of mercury; the water-tap being suddenly opened, a strong flow of water is caused to fall into the basin at a height of from 8 to 10 centimetres from its bottom. On turning off the flow of water again, it will be seen that on the surface of that fluid there float about bubbles of mercury,

usually exhibiting a diameter of only 1 centimetre, but occasionally some are found of two or three times that size. As a rule these bubbles are very ephemeral; now and then, however, it happens that some may be caught along with a quantity of water in a small beaker glass, and on the mercurial bubbles bursting, it will be seen how very small a quantity of mercury these bubbles consist of. Professor Hofmann mentions that he saw this experiment first exhibited in the lecture-room of the Royal College of Chemistry, London, when, twenty years ago, Professor Melsens, from Brussels, was on a visit there.

Caustic baryta is likely to become of considerable use for industrial purposes. M. Nicklès has described its mode of preparation. It appears that four operations are required:—(1) Conversion of native sulphate of baryta into sulphide of barium; this is effected in a continuous manner, in a peculiarly constructed furnace, the sulphate being previously mixed with a reducing substance; (2) the conversion of the sulphide of barium into hydrate of baryta, by means of hydrated oxide of zinc; (3) dehydration of the hydrate of baryta by ignition along with sawdust; (4) regeneration of the substance which has served for the desulphuration of the sulphide and obtaining of sulphur.

M. E. Underhold states that the hardest steam-boiler incrustations are formed when the quantity of carbonate of lime amounts to from 20 to 25 per cent. of the entire mass. He has found, by an experience extending over several years, that some kinds of clay when suspended in the water contained in steam-boilers, prevent the particles of carbonate and sulphate of lime dissolved in the water, even if the latter is very hard, from clinging together and becoming fixed to the sides of the boilers, forming there a hard incrustation. A series of experiments, made on purpose and continued for a sufficient length of time to yield a reliable result, has fully proved that the addition to the feed-water of the steam-boilers of fatty clay, especially that known as fuller's-earth, entirely prevents boiler incrustations, even where, of necessity, very hard water has to be used as feed-water. A loose soft mud is deposited as soon as the motion of the water due to the boiling ceases on cooling. This mud readily runs off on opening the valve of the boiler.

Some valuable sulphur deposits have been discovered in the island of Saba, Netherlands, West Indies. The rock composing almost the entire formation of Saba is trachytic porphyry, which contains glassy felspar and hornblende in crystals, disseminated through a dark reddish-coloured vase. The sulphur deposit is located on the northern part of the island of Saba, and extends for a distance of more than a mile along the sea line. The stratum of

sulphur varies in thickness from 15 to 50 feet; its elevation above sea-level varies from 45 to 200 feet. This island has a surface of about 9 English square miles, or 5760 acres, and contains 1794 inhabitants.

6. ENGINEERING—CIVIL AND MECHANICAL.

The Suez Canal.—The past quarter will long be memorable in the annals of Civil Engineering for the completion and successful inauguration of one of the most wonderful works of modern times. The Isthmus of Suez Canal, just completed, is, however, the realization of no modern conception. The idea of traversing that isthmus, or at least the greater portion of it, is so ancient that the original author of it cannot now be named; but evidences remain to show that, at some very remote period, a canal really did exist between the river Nile and the Red Sea. As far as can be ascertained it was undertaken by Necho, about six centuries before the Christian era, and subsequently completed by Darius. There exists amongst ancient writers some difference of opinion as to the precise character of the canal and its exact route, but there can be no doubt that a canal was once made, extending from the Nile to the Bitter Lakes, a distance of about thirty-four miles, which, being filled with fresh water by the rising of the Nile, was navigable for at least such portion of the year as the Nile was in flood: it is also certain that a smaller canal was continued from the Bitter Lakes to the Red Sea, near Suez. These works, which for many centuries had been allowed to fall into decay, were restored about A.D. 649 by the Caliph Omar; but instead of the restored canal joining the Nile, near Bubastis, it curved southward to Cairo, and was named the 'Canal of Cairo.' This canal appears to have continued open until about the year A.D. 767, affording means of water communication between the Nile and the Red Sea. Subsequently to the above date there do not appear any records of its existence; but at the latter part of the last century the Emperor Napoleon Bonaparte, during the time of the Egyptian expedition, caused a complete survey of the old canal and of its route to be made by M. Lepère. That officer's report was dated in 1799; but in consequence of the withdrawal of the French from Egypt no further action was taken in the matter.

The next report on the subject which deserves notice was that of Captain Chesney, of the Indian army, in 1830, who proved the perfect practicability of the project, and his views were subsequently verified by surveys undertaken under Robert Stephenson. For many years previously Linant Bey had considered the project of cutting a navigable canal across the Isthmus; and in 1845 an

association was formed with the view of carrying the work into effect. Prior to that date, however, M. de Lesseps had formed his conclusions on this subject; and in 1854 he suggested his ideas to Said Pacha, by whom the project was warmly entertained. A commission, composed of the principal engineers of Europe, was convened to examine the scheme, who visited the site in November, 1855, and in January following they submitted their report, in which the undertaken was represented as easy of accomplishment and certain of success, and the estimated cost was then set down at 200,000,000 francs. A concession was shortly afterwards given to M. de Lesseps for the construction of the canal; and after further careful investigations the works were set in hand, the completion of which was celebrated by the opening of the entire canal on Wednesday, the 17th November last.

The course of the canal is from Port Said, on the Mediterranean, through Lakes Menzaleh and Ballah, after which it is cut through some high ground at El Guisr, which separates Lake Ballah from Lake Timsah. Between the latter lake and the Bitter Lakes lies also a length of high land, extending from the shore of Lake Timsah to Serapeum, after which the canal enters the district of low, swampy land, known as the Bitter Lakes. It then reaches high ground once more at Chalouf, and for the remainder of the distance to Suez passes through high land in deep cuttings. The length of the canal is about 100 miles. The total expenditure upon the canal has been 434,000,000 francs; but according to a statement recently published the net cost, after allowing for the present value of plant, &c., has been 216,000,000 francs.

Blackfriars Bridge.—In addition to the above great international work, there have been completed, within the period under review, two important engineering projects within the city of London, namely, the reconstruction of Blackfriars Bridge across the Thames, and the erection of a viaduct across the Holborn Valley.

Old Blackfriars Bridge was first thought of in 1754, at which date there existed no means of communication across the Thames between London and Westminster Bridges; and in 1756 an Act was obtained for the erection of a bridge across the Thames in the neighbourhood of Fleet Ditch. On 26th April, 1760, a contract was entered into with a Mr. Phillips for the construction of a bridge for 110,000*l.*, from the designs of Mr. Robert Mylne. On the 31st October, in the same year, the first stone was laid by Sir Thomas Chitty, Lord Mayor, and the bridge was opened to foot passengers on the 19th November, 1766. It was not, however, until the 19th November, 1769, that it was finally completed and opened for wheel traffic. On the 8th June, 1864, old Blackfriars Bridge was closed, and the traffic diverted over a temporary

wooden structure erected by its side. The design for the new bridge was prepared by Mr. J. Cubitt, and the estimated cost was 269,000*l*. Space will not admit of a detailed description of this bridge, which was opened by the Queen in state on the 6th November last.

Holborn Viaduct.—On the same date the Holborn Viaduct was completed and declared open to public traffic. This important work, extending from the top of Holborn Hill on the west to the top of Skinner Street Hill on the east, crosses over the ancient valley of the Old Bourne, affording a straight line of communication where two steep hills previously impeded the traffic. The works have been carried out from the designs of Mr. Heywood, the city architect, at a total cost of about 2,000,000*l*.

Proceedings of Societies.

Institution of Civil Engineers.—Considerable indignation has been recently aroused amongst the members of the engineering profession in England and India, in consequence of a Circular Order issued by the Government of India, from which it was distinctly to be inferred that the practice of accepting bribes from contractors and others was recognized by the profession in England. At the first ordinary meeting of the Institution, on the 9th November, the President reported that on receipt of a copy of the Order in question, a meeting of the Council took place, at which a series of resolutions were passed totally repudiating the calumny, copies of which were forwarded to the Secretary of State for India. At a deputation of the Council, which subsequently waited upon the Duke of Argyll, his Grace promised to forward the representations of the Institution to the Government of India, and to call for some explanation as to the circumstances which led to the publication of the Order; and in a subsequent letter to the President of the Institution, his Grace declared that "he regarded with implicit confidence the indignant repudiation of the Institution of any recognition of the practice referred to in the notification."

Society of Engineers.—The principal paper which has been read before this Society in the present Session, is one by Mr. P. F. Nursey, on "English and Continental Intercommunication." After referring to the present defective means of transit across the British Channel, the author briefly alluded to a few impracticable suggestions which have, from time to time, been proposed for the purpose, and then referred more in detail to those projects which have been put forward by experienced engineers. These may be divided into three classes, namely:—1. Those for tunnelling under the bed of the sea between England and France. 2. Schemes for carrying a

railway through submerged tubes laid at the bottom of the sea; and 3. For the improvement of the passage-boats, or, in other terms, the construction of a huge Steam Ferry between the two countries. A fourth class of projects may be enumerated, namely, those having for their object the construction of a high-level bridge across the Channel, but such hardly come within the category of practical schemes. That which can be constructed at least cost and with most expedition is the Channel Ferry project, and this we are inclined to think will, for the present at least, be found the most practical solution of the difficulty.

New York Society of Practical Engineering.—At a meeting of this Society, on 13th October last, a most useful and practical paper was read by Mr. C. Williams, C.E, on "Railway Accidents and the Means of Prevention." In the absence of wooden tie sleepers, the author advocated the laying of rails upon sleepers bedded upon sand confined in trenches formed either transversely or longitudinally with the track. The importance of securely attaching the rails to the substructure was dwelt upon; and, lastly, improved fish-joints and methods for avoiding the breaking of railway carriage axles were discussed, and the methods for effecting such means of security were dwelt upon at some length.

Literature.

'The Theory of Strains in Girders and similar Structures,'* by Bindon B. Stoney, B.A.—The first volume of this work appeared three years ago. The present volume treats of the subject of girders under compression and in tension, as well as elasticity, temperature, and the practical designing and estimating of girder-work; and in the former part of the volume numerous references are made to the experiments carried out by Mr. Kirkaldy and Mr. Hodgkinson. As a text-book for practical engineers this will be found a useful work, but it would be impossible to enter fully into its merits within the space to which we are limited.

'A Practical Treatise on Concrete, and How to make it; with Observations on the Uses of Cements, Limes, and Mortars,'† by Henry Reid, C.E.—At the present day when the use of concrete and cements is being so largely introduced into almost all engineering works, a more perfect knowledge of their properties is a subject much to be desired, and every fresh information coming from a reliable source is much required. During the earlier period of the introduction of concrete, which, in this country, is attributed by General Pasley to Sir Robert Smirke, it was regarded as being only fitted for foundations, or hidden work of a similar kind; but of late years that material has acquired a higher standard, and is now

* Longmans, Green, & Co., London. † E. and F. N. Spon, London.

being extensively employed in the construction of buildings of various kinds with most satisfactory and economical results. The preparation of concrete is treated very fully by Mr. Reid, who devotes distinct chapters to lime concretes, concretes with compound matrices, Roman cement concretes, and concretes made with Portland cement. He also gives descriptions of machinery for mixing concretes and mortars, as well as remarks on building by frames. In conclusion, some general observations of considerable value are given on the advantages possessed by Portland cement as a building material, in the course of which he mentions the success which has resulted from the use of such concrete as a material for pavements. Altogether this is a very useful work, which may beneficially be consulted by all classes interested in the use of concrete.

7. GEOLOGY AND PALÆONTOLOGY.

(Including the Proceedings of the Geological Society, and Notices of Recent Geological Works.)

Memoirs of the Geological Survey.—Two of these Memoirs, forming an important contribution to British Geology, have reached us during the past quarter. One is a very elaborate 'Essay on the Triassic and Permian Rocks of the Midland Counties of England,' by Edward Hull, M.A., F.R.S., &c. (now Director of the Geological Survey of Ireland). No less than twenty sheets of the 'Geological Survey' (one-inch) maps are referred to in this Memoir, which include parts of the counties of Gloucester, Hereford, Worcester, Warwick, Leicester, Stafford, Salop, Denbigh, Flint, Cheshire, Derby, Notts, York, and Lancaster. The rocks are treated in ascending order, under the following headings, or general classification:—

TRIASSIC SERIES	A 1.	Rhætic, or Penarth Beds.	
	A 2.	New Red Marl (Keuper).	
	A 3.	Lower Keuper Sandstone (Letten Kohle ?).	
	(B.	Muschelkalk, wanting in England).	
	C 1.	Upper Mottled Sandstone	(Bunter Sandstein).
	C 2.	Pebble Beds	
	C 3.	Lower Mottled Sandstone	
PERMIAN SERIES ..	1.	Upper Permian (Zechstein).	
	2.	Lower Permian (Rothe-todte-liegende).	

The Lower Permian series may be arranged under two distinct types of strata, called respectively the "Salopian" and the "Lancashire," which differ lithologically, and were deposited in separate hydrographical basins, the disconnecting barrier having been produced by the upheaval of the Lower Carboniferous rocks along a tract of country crossing from east to west below the central plain of Cheshire. Our readers will remember Mr. Hull's paper, recently

read before the Geological Society, in which he entered fully upon this question.

The unconformity is noticed between the Triassic and Permian series, which was pointed out by Professor Sedgwick more than forty years ago; the newer beds rest indiscriminately on any of the older formations, whether Silurian, Devonian, Carboniferous, or Permian.

The lithological peculiarities of the beds exhibited in different localities and their organic remains are noticed. Though it is as well to mention that the subdivision of the Bunter Sandstone, or Lower Trias, into three members, which was propounded by Mr. Hull in the course of his detailed examination of the rocks over a large area, was altogether dependent on inorganic evidence.

Some little space is of course devoted to the beds of Rock-salt interstratified with the Red Marls and clays of the Keuper. The Rhætic, or Penarth Beds, are also briefly noticed; but these beds have not yet been traced farther northward than the outlier of Copt Heath, near Birmingham, and at Abbots Bromley, in Staffordshire. Mr. Hull is inclined to regard these beds as referable to the Triassic formation, although it seems to us better to regard them as passage-beds between the Lias and Trias—the lower beds passing into the latter, the upper being more closely related, and sometimes appearing to graduate into the Lower Lias above.

The Physical Geology of the Permian and Triassic periods are treated of; also the distribution of the Coal Measures beneath them.

The Bunter Sandstone is considered as a source of water-supply, and is regarded, with the exception perhaps of the Chalk and Lower Greensand, as by far the most important water-bearing formation in England.

In an appendix is given a list of the Fossils in the Warwick Museum, from the Keuper and Permian Sandstones, by the Rev. P. B. Brodie, revised by Mr. Etheridge, Palæontologist to the Survey.

The second Memoir is on the 'Geology of the Carboniferous Limestone, Yoredale Rocks, and Millstone Grit of North Derbyshire, and the adjoining parts of Yorkshire,' by A. H. Green, M.A., F.G.S., Dr. C. Le Neve Foster, B.A., F.G.S., and J. R. Dakyns, M.A. They give a detailed description of the geological structure of the district, together with observations on the physical features and drainage, followed by an appendix, giving a list of the Carboniferous Limestone fossils of Derbyshire, furnished by Mr. Etheridge.

The formations described in this Memoir are as follow:—

RECENT	Alluvium and River Gravels.
POST PLIOCENE ..	Boulder Beds.
CARBONIFEROUS ..	Lower Coal Measures, or "Ganister Beds."
	Millstone Grit.
	Yoredale Rocks.
	Carboniferous, or Mountain Limestone.

Both these Memoirs are well illustrated with sections and diagrams. The authors give due credit to other observers who have previously described these districts. They will be found of the greatest service to all who may need to consult them, either for professional purposes or as amateur geologists.

In November, 1867, the Rev. Thomas Wiltshire, M.A., F.G.S., read a highly interesting paper before the Geologists' Association, "On the Chief Groups of the *Cephalopoda.*" This has just been published, and will be found very useful by the student. The author touches upon the structure and habits of these animals, and gives schedules of the recent and fossil Cephalopods, wherein are analyses of the families and genera; he also gives an appendix on the range of the genera in geological time.

Mr. E. D. Cope has published the first part of an elaborate 'Synopsis of the extinct Batrachia and Reptilia of North America.' He has thought it best to describe only those species and types which are new, and those portions of imperfectly known forms which will throw additional light on their relations and affinities.

In the course of his investigations, prosecuted during the past six years, with reference to the structure and relations of the extinct Reptilia, the following general conclusions have been arrived at, besides many of lesser significance:—

1. That the *Dinosauria* present a graduated series of approximations to the birds, and possess some peculiarities in common with that class, standing between it and the *Crocodilia.*
2. That serpents exist in the Eocene formations of this country.
3. That the *Chelydra* type was greatly developed during the American Cretaceous period; and that all the supposed marine-turtles described from it are really of the first-named group.
4. That the *Reptilia* of the American Triassic period are of the *Belodon* type.
5. The discovery of the characters of the order *Pythonomorpha.*
6. The discovery of the characters of the order *Streptosauria.*
7. The development of the characters of numerous members of the Batrachian sub-order *Microsauria* in the United States.

The Memoir is illustrated with eleven plates and numerous woodcuts. Mr. Cope's work is peculiarly interesting, as bearing upon the researches of Professor Huxley on the affinities of the *Dinosauria* with the class *Aves* independently carried on in this country.

'The Geology and Mineral Veins of the Country around Shelve, Shropshire, with a Notice of the Breidden Hills,' by G. H. Morton, F.G.S., F.R.G.S.I., President of the Liverpool Geological Society (extracted from the Proceedings of the Society), Liverpool, 8vo, pp 41.

This work treats of both the Geology and the Archæology of

Shelve, which is situated in western Shropshire. The lead mines were worked in the Roman period, as shown by their coins, pottery, and mining implements; pigs of lead bearing on their stamp the name of Hadrian have been found there. The remains of Roman encampments exist in the neighbourhood, as well as several Druidical circles; the largest of which, the Circle, or "Hoar stones," has still thirty-two stones standing, and seems originally to have contained thirty-six.

Very red copper ore, "Redruthite," has been found in the neighbourhood, but workings have only lately been commenced. The average direction of the greatest number of the veins is W.N.W. by E.S.E.; most of them are simply fissures in the rock (Lower Silurian), which is prominently developed in this district, filled with Barytes Calcite and irregular strings and nests of Galena and Blende, interspersed with fragments of the slate-rock. The author observes, "It is remarkable that in the Upper Llandeilo rocks the veins principally contain *Barytes*; the Lower Llandeilo rocks, *lead*; and the Cambrian rocks, *copper*."

There are several interesting sections given, showing the disturbances caused in the Lingula flags, Llandeilo and Cambrian beds, &c., by the eruptive intrusion of greenstone and other trap-rocks. Lists of the fossils found in these formations and maps of the mineral veins are also appended.

The Breidden Hills, about ten miles N.W. of Shelve, range to the height of 1200 feet above the sea-level, are surrounded by the Llandeilo strata, and are interesting from the many varieties of porphyritic and amygdaloidal greenstone, trap-breecia, and ash, of which they are composed.

The 'Geological Magazine' for October, November, and December contains an abundant supply of interesting papers, only a few of which we have space to notice.

1. A novel theory of the formation of the Chesil Bank is propounded by Messrs. H. W. Bristow and W. Whitaker. The question they deal with is simply the cause of the position of the beach, separated as it is from the mainland throughout its greater length by a strip of water called "the Fleet."

The authors are of opinion that this channel was formed subsequently to the heaping up of the shingle, which they think was originally formed against the land. East of Abbotsbury the ground is comparatively low, and numerous streams run into the Fleet; while for some distance west of this village there are no streams, the ground is much higher, with cliffs, and the beach is not separated from the land. The conclusion arrived at is that after the beach was formed against the land, these streams in flowing down towards the sea would turn eastwards for some distance before filtering through the shingle (as is the case with streams west of Burton

Bradstock), and as they are not far apart they would in time meet and form a continuous channel (the Fleet), which would be widened and kept clear by land-waters, aided perhaps by tidal action as suggested by Mr. Evans.*

2. Mr. Ray Lankester records the discovery of *Machairodus* in the Forest-bed of Norfolk; and from the researches of Mr. Pengelly, no doubt can remain that the great sabre-toothed tiger should be retained on our list of British Fossil Mammals.

3. Professor Owen describes two new Ichthyodorulites, *Lepracanthus Colei* from the coal-shale of North Wales, and *Hybodus complanatus* (of Neocomian age) from the Iguanodon quarry of Mr. Bensted, at Maidstone.

4. The Rev. T. G. Bonney discusses the origin of some supposed "Pholas-burrows" in the Ormesheads. He is inclined to attribute these holes (with Dr. Buckland and M. Bouchard-Chantereaux) to the agency of land-snails, probably *Helix aspersa;* but we expect that many will still think it safer to regard them as due to atmospheric influences, and that subsequently snails have taken up their abodes in the hollows.

5. Mr. C. E. De Rance writes on the Surface-Geology of the Lake District.

6. Dr. H. A. Nicholson describes some plant-remains from the Skiddaw slates, and Mr. Henry Hicks some still older from the Arenig beds of St. David's.

7. Dr. Ruskin continues his researches on Banded and Brecciated Concretions.

8. Mr. Scrope combats some of Mr. Mackintosh's statements of the marine origin of certain terraces, popularly called "Lynchets" or "Balks." These he regards as of artificial origin, to be owing to the disturbing action of the plough and the mattock on the surface-slopes, aided by downward rain-carriage of the loosened soil—a process which, he adds, is *visibly* going on wherever a hill-side is under cultivation.

9. Professor Harkness contributes a paper on the Middle Pleistocene Deposits, having reference to the beds in England, Scotland, and Ireland.

10. Mr. R. Tate furnishes some notes on new and little-known Liassic Brachiopoda, and gives a table showing the distribution of all the species known to occur in the Lias of Britain.

11. The Earl of Enniskillen, following Sir P. Egerton's example, supplies an alphabetical catalogue of type-specimens of Fossil Fishes in his collection at Florence Court, which he also adds are open to the inspection of any geological or palæontological student.

12. Mr. W. H. S. Westropp notices the occurrence of Albite in the granite of Leinster.

* When this paper was read at the Geological Society's meeting.

We regret to record the death of Dr. R. N. Rubidge, F.G.S., &c., a gentleman well known for his investigations into the geology of South Africa.

Proceedings of the Geological Society of London.

The 100th No. of the Society's 'Quarterly Journal' is now before us. It is hardly so bulky as usual, for besides two postponed papers it only contains the communications read at one (the last) meeting of Session 1868–9, and very many of them are merely published in abstract. One of these papers is by Mr. Whitaker, and the subject—"The Connection of the Geological Structure and Physical Features of the South-east of England with the Consumption Death-rate"—is a comparatively new and a very important one.*

We will briefly notice one or two of the papers contained in this Journal.

Sir Philip Egerton, Bart., describes two new species of *Gyrodus*: one from the Middle Oolite on the east coast of Sutherlandshire; the other, several specimens of which exist, is from the Kimmeridge clay of Kimmeridge.

Mr. J. W. Hulke, F.R.S., contributes two papers. In the first he describes a large Saurian humerus from the Kimmeridge clay of the Dorset coast. A careful examination and comparison of it with other reptilian remains show it to possess strong crocodilian affinities, but to differ from any genus yet completely known. That to which it appears most closely related is a bone (now in the British Museum) upon which Dr. Mantell founded his genus *Pelorosaurus*. The immense size of the Saurian to which this humerus belonged may be judged from the bone measuring 31 inches in length, and the girth of the shaft near the middle being 11 inches. In the second paper, Mr. Hulke furnishes notes on some fossil remains of a gavial-like Saurian from Kimmeridge Bay, wherein he establishes its identity with Cuvier's "Deuxième Gavial d'Honfleur" (*Steneosaurus rostrominor* of G. St. Hilaire), and with Quenstedt's *Dakosaurus*.

Mr. W. T. Blanford, F.G.S., who was attached as geologist to the Abyssinian expeditionary force, here brings forward some of the results of his observations while acting in this capacity. Recent and Post-Tertiary, Tertiary, Cretaceous, Jurassic, and probably Triassic rocks, are represented in Abyssinia. Many fossils were collected, and Mr. Etheridge remarked on the similarity of the Oolitic specimens to those from the Cotteswold Hills, and also to some from the Holy Land. In speaking of the denudation to which the country has been subjected, Mr. Blanford stated that there were no marks of glaciation discernible, the excavation of the valleys

* This paper has appeared in the 'Geological Magazine.'

being apparently due to the excessive rainfall. There was not a trace of marine denudation over the surface examined.

Mr. Mackintosh, F.G.S., contributes an interesting paper "On the Correlation, Nature, and Origin of the Drifts of North-west Lancashire and a part of Cumberland, with remarks on Denudation."

Mr. J. Wood Mason, F.G.S., describes a new Acrodont Saurian from the Lower Chalk, near Folkestone, to which he assigns the name *Acrodontosaurus Gardneri*.

Mr. Searles V. Wood, jun., F.G.S., and Mr. F. W. Harmer, bring forward evidence of a peculiar case of intra-glacial erosion near Norwich.

Their observations tend to show that after the deposition of the uppermost bed of the Lower Glacial period there was a physical break, a suspension of deposit, during which lapse of time an erosion took place, sweeping out some of the glacial beds already formed, and extending some way into the Chalk beneath. Into the trough thus formed the succeeding drifts of Middle Glacial age were deposited, as well as upon the hills in regular order above those Lower Glacial beds unaffected by the denuding agency. A section exhibiting these phenomena has recently been disclosed by some new drainage works at Norwich, which the authors hoped by their communication to induce geologists to visit. Some little time ago, Mr. Harmer described to the Society a "Third Boulder-clay" which he found lying in the bottom of the Yare valley. This may now be explained from the section described in the present paper; the authors are inclined to regard it as a portion of the Great (or Upper) Boulder Clay, which was deposited at this low level owing to the intra-glacial erosion which had taken place before its deposition.

Mr. J. W. Flower, F.G.S., records some recent discoveries of flint implements in the drift of Norfolk and Suffolk, concluding with some observations on the theories accounting for their distribution. The distribution of the drift-beds he is disposed to attribute, with the French geologists, to some powerful cataclysmal action, perhaps of short duration, and several times repeated,—an opinion in which it appears but few of our own countrymen coincide.

8. METEOROLOGY.

The sudden change of weather noticed in the note to our last Chronicle, p. 549, forms the subject of an interesting paper in the last number of the 'Journal of the Scottish Meteorological Society.' This change occurred in the afternoon of the 28th of August. The preceding days had been exceptionally warm, especially in

England; but on that evening a current of polar air began to flow southwards, causing a fall of temperature of 40° within ten or twelve hours at several stations (35° at Marchmont Dunse in seven hours), and producing the unusual phenomenon of a smart night-frost before the end of August.

The same number of the journal contains a paper by Mr. Milne Home "On Rotatory Storms," which he seeks to explain by the analogy of other known atmospherical disturbances. The paper, which is well illustrated, consists of a series of extracts from the reports of various observers of waterspouts and whirlwinds which they have witnessed, and from Dr. Baddeley's work on the Dust-storms of India. The reasoning on the data thus collected is very brief, and not altogether satisfactory. Mr. Home assumes that all our ordinary storms are simply gigantic whirlwinds, generated by some unknown agency, probably the friction of interfering air-currents at a high level in the atmosphere. Two such currents would generate a vortex of conical shape, with great barometrical rarefaction in the centre, of which the point may reach the earth, and produce a reduction of pressure and a great disturbance of the atmosphere. There are, however, several flaws in this chain of reasoning, not the least important of which is the attempt to explain the sudden fall of temperature in the rear of the storm, which accompanies the north-west wind felt there, by the supposition that the centrifugal force of the vortex throws out a mass of heated air into the upper region of the atmosphere, and thereby displaces the colder strata at that level, forcing them down to the ground.

A more important paper on a cognate subject is Mr. Blanford's investigation as to the origin of the Calcutta cyclone of Nov. 1, 1867, which appears in vol. xvii. of the Royal Society's 'Proceedings.' Mr. Blanford is led by the data he has collected to the belief that the cyclone was generated on Oct. 27 in the neighbourbood of the Nicobar Islands. For a day or two previous there had been a barometrical depression at that point, when three distinctly-marked wind-currents commenced flowing round it, and ultimately coalesced to form the cyclone.

If this idea be true, it would tend to show that the origin of the barometrical depression, the nucleus of the storm, was to be sought for in some agency independent of the mutual action of the wind-currents, a result apparently at variance with the general tendency of Mr. Meldrum's investigations into the analogous storms of the South Indian Ocean, which appear to indicate, as already remarked by us, that the barometrical depression is generated between pre-existing currents of air which subsequently form tangents to the cyclone.

The Report of the Meteorological Committee for Calcutta for

1868 has just appeared, and it shows that Mr. Blanford is getting his work well in hand, and gives a fair promise of future good results.

The next number of the 'Proceedings' (No. 114) contains a paper by Sir E. Sabine, "On the Results of the First Year's Performances of the Photographically Self-recording Instruments at Kew." The mean values for the several elements are compared with those obtained by discussion of the observations for Nertschinsk and Barnaoul, published by Kupffer, and the results are very interesting, as showing the contrast between insular and continental climates.

In connection with Siberia, we may notice that a brief account of the climate of Sitka and the adjacent country is to be found in vol. viii. of the 'Transactions of the Swedish Academy,' recently published. It is in German, and is contained in a letter from Herr Furuhjelm, of Helsingfors, who lived in that colony for many years. Little was known of its climate before; and what we now learn of it shows that "Walrussia" is anything but an enviable place of residence, owing to its excessive dampness.

Professor Wild, the new Director of the Central Physical Observatory at St. Petersburg, has lost no time in bringing out the volume of 'Annales' for 1865, the issue of which had been interrupted since the death of Kupffer. He tells us in the preface that a complete change will soon be made in the form and contents of the publication. The metrical scale is to be at once introduced throughout the empire, and the speedy adoption of self-recording instruments is announced as probable.

The Journal of the Austrian Meteorological Society contains a very interesting account, by Abich, of two hail-storms experienced at Tiflis in May last. The stones, which were of great size, were crystallized in forms well known in mineralogy. How these stones remained suspended in the air long enough for crystals of such size and regularity to be formed is a question which Abich does not attempt to solve. It is most fortunate that the occurrence came under the notice of so able a mineralogist as he is, and we hope that it will find its way into some of our geological journals. The connection between meteorology and physical geology is close enough, but a bond of union between it and mineralogy is at least unexpected.

Herr von Freeden has brought out No. 2 of the 'Mittheilungen' of his office, the weather calendar for North-west Germany, being a discussion of his own observations carried on for ten years at Elsfleth, near Bremen. The whole treatment of the subject is very thorough, and the paper is a most useful one, as a record of what may be effected by a single observer keeping a registry for a long

period on a definite system. There is one special table which calls for notice, that of the daily temperature of the river Weser. The results tend to set at rest the moot question of the relation between water and air temperature. They show that while the water was permanently warmer than the air to the extent of 3°·5 F. on the mean of the year, its changes followed those of the air in point of time, but were less in extent. There are several very suggestive deductions from the tables, and the calendar concludes with some useful practical weather rules.

We mentioned lately that M. Coumbary had organized a Meteorological service in the Turkish empire. He has now begun to publish a monthly *résumé* of his observations. The provincial stations from which returns for September are published are: Smyrna, Beyrout, Diarbekir, Bagdad, Fao, Rustchuk, Sulina, Varna, Trebizonde, and Salonica. M. Coumbary is very anxious to obtain daily telegraphic reports from Bombay, an idea even more novel than that which is already an accomplished fact, the regular daily service across the Atlantic.

The 'Bulletin' of the new central observatory at Montsouris, near Paris, has now assumed a definite shape as regards its contents. It gives for the observatory eight readings daily of the various instruments, with reports of the state of the atmosphere and the amount of cloud. Observations are also printed from some stations near Paris, as well as from six stations on the coast; the same as are published in our own 'Daily Weather Report,' and the daily summary of British weather supplied by telegraph to the Ministère de la Marine is appended.

Le Verrier's 'Atlas Météorologique' for 1868 contains, in addition to the usual charts and accounts of the thunder and hail storms, and a general sketch of the rainfall in France during the year, a number of memoirs of very varied scope. Among them we find one by M. Rayet, on the climate of the Isthmus of Suez; another, by M. Belgrand, on the rainfall in the Seine basin at the Quaternary epoch (this latter might almost as suitably find a place in the 'Journal of the Geological Society'); and a number of special notices from the various departments. There is, however, a paper by Mr. Buchan, "On the Meteorology of North-west Europe in 1868," which calls for remark. The author is well fitted for the preparation of such a paper by his experience in studying storms; but in our opinion the value of his reasoning is much diminished by the introduction of too much theory. More than once we have a long train of argument depending on a succession of "ifs." This is not logical reasoning at all, and is rather out of place in a paper like that we are discussing. This tendency to theorize we have before had to notice in Mr. Buchan, as a blemish on his work. Let

us have the facts discussed honestly, and few can do that better than he can; but let the theories be kept to be aired before scientific societies and published in their journals. Meteorology has suffered more than most sciences from building castles in the air. Let us lay a firm foundation before we begin the structure.

9. MINERALOGY.

"HERE there is no room for might, could, would, or should,—but it *is* so; *native lead* in melaphyre!" With these confident words Dr. Zerrenner introduces to us the discovery of native lead imbedded in a rock at Stüzerbach, in Thuringia.* And, in truth, his expressions of assurance are by no means ill-timed; for there is confessedly a little scepticism lurking in the minds of many of us as to the genuineness of such a find—scepticism which is perhaps pardonable enough when we remember how often the mineralogist has been bitten by describing old shot and rifle bullets as natural productions! In the case before us, however, there seems no reason to think that Dr. Zerrenner has misplaced his confidence—judging at least from the illustration which shows the globules of lead imbedded in the cavities of the amygdaloidal melaphyre, and more especially from his description which refers to it as running through the rock in strings.

Native lead is also said to have been found, within the last few years, associated with gold in the auriferous drifts of some of the deep mining "leads" in Victoria.† Quite recently, too, we have seen some reputed native lead in the form of rounded shot, coated with a whitish incrustation, and accompanied by magnetic iron-ore and native gold, from the old auriferous district in Co. Wicklow.

On a question so obscure and enigmatical as that of the origin of the diamond, every tittle of evidence is worth recording. Dr. Göppert, in his famous essay which gained a prize at the Haarlem Academy in 1864, argued strongly in favour of the formation of this mineral by the wet way. He now publishes an account of certain diamonds containing organic structures tending to confirm his views.‡ Two diamonds in the Royal Mineralogical Museum in Berlin were found to enclose numerous green cells closely resembling those of many algæ. One of the diamonds, weighing 263 milligrammes, contains a very large number of perfectly round

* 'Berg und Hüttenmännische Zeitung,' No. 12, 1869, p. 105; also, 'Mineralogische Nachrichten,' 1869, p. 33.

† 'The Gold-fields and Mineral Districts of Victoria.' By R. Brough Smyth. Melbourne, 1869. Pp. 420.

‡ 'Ueber algenartige Einschlüsse in Diamanten, und über Bildung derselben.' Abhandl. d. Schlesisch. Gesellsch. (§ Naturwiss. u. Medicin), 1869, p. 62.

green granules, which appear to be isolated cells not unlike those of *Protococcus pluvialis*. The new species is accordingly named *P. adamantinus*. In the second diamond, weighing 345 milligrammes, the cells are less round and more elongated in form, while they frequently unite so as to form a loose parenchymatous tissue: they find their best representatives in *Palmogloea macrococca*, and Göppert has accordingly ventured to name the new diamond-plant *Palmogloeites adamantinus*.

Once again, the old mistake has been repeated in Australia. In the New England district a stone was found, about the size and shape of a duck's egg, and weighing 6 oz. 13 dwts. 12 grs. troy. Of course it was taken for a diamond, and rumour was soon rife as to its prodigious worth. A few days after announcing the discovery, the 'Australian Mail' coolly adds, "The 'great diamond' which had created so much sensation has proved to be a piece of crystal-quartz!"

Hitherto crystallized quartz has been artificially prepared only by wet processes. But the presence of this mineral in rocks usually referred to an igneous origin, naturally leads to the belief that it may certainly be produced also in the dry way. Acting on this belief, Gustav Rose has recently experimented on the fusion of silica, adularia, and other minerals, in salt of phosphorus and in borax.* His experiments were conducted on a large scale at the furnaces of the Royal Porcelain Manufactory at Berlin. Crystallized silica was thus obtained, but in the form of small six-sided plates, unlike the crystals of common quartz, from which it also differed in having the low density of 2·3. Rose has thus produced not ordinary quartz, but Vom Rath's curious new species Tridymite, which has been already described in this Journal. Whilst he has thus obtained artificial tridymite, he does not despair of forming artificial quartz by a modification of his process.

Spectrum analysis has been applied, by Vogelsang and Geissler, to the difficult question of determining the chemical nature of the fluid found enclosed in minute quantity in the cavities of certain quartz-crystals.† Fragments of quartz were placed in a small retort, which was connected with an air-pump and exhausted; then by the application of heat the quartz decrepitated, and the evolved vapour was examined in a Geissler-tube. The presence of carbonic acid was thus abundantly proved, and this was confirmed by the turbidity which it produced in lime-water.

Among some minerals examined by Herr Petersen from the St. Wenzel mine, near Wolfach, in Baden, he finds a new species belonging to the interesting group of antimonial sulphides of silver.‡

* 'Monatsbericht d. k. preussichen Akad. d. Wiss.,' 1869, p. 449.
† 'Rhein Verhdlg.,' xxv. Sitzungsber, p. 77.
‡ Poggendorff's 'Annalen,' No. 7, 1869, p. 377.

The new mineral is to be called *Polyargyrite* or *Weichglaserz.* It occurs in small iron-black crystals, belonging to the cubic system, and consisting of 12 $Ag S + Sb S_3$. Now that we are acquainted with another member of these antimonial sulphides, it may be well to compare the composition and crystalline system of these minerals, since it is hardly probable that another species of this group will be found containing more silver-sulphide than is present in polyargyrite.

Miargyrite	$Ag S + Sb S_3$	oblique
Pyrargyrite	$3 Ag S + Sb S_3$	hexagonal.
Stephanite	$6 Ag S + Sb S_3$	rhombic.
Polybasite	$9 Ag S + Sb S_3$	hexagonal.
Polyargyrite	$12 Ag S + Sb S_3$	cubic.
Argentite	$Ag S$	cubic.

Another new mineral from the same locality is described under the name of *Wolfachite.* It crystallizes in the rhombic system, and contains:—$Ni S_2 + Ni (As_2 Sb_2)$.

English ears will not easily get reconciled to the sound of *Wollongongite*—the name which Professor Silliman proposes for a new native hydrocarbon, which promises to become of great technical importance.* It seems to be a variety of cannel, occurring abundantly in the Wollongong district of the Illawarra coal-field in New South Wales. On distillation it yields a large volume of gas of remarkably high illuminating power.

A mineral mistaken for augite has lately been found by Professor Brush to be a new variety of chrysolite, and he has accordingly named it *Hortonolite,* in recognition of Mr. Silas Horton's courtesy in calling his attention to it.† It occurs in the form of dull blackish rhombic crystals, in the iron mine at Monroe, Orange Co., New York; and from its abundance it may become of some commercial importance as an iron-ore. It is chemically a chrysolite, containing iron, magnesia, and manganese.

Among the fine pebbles of stream-tin from Durango, in Mexico, it is well known that the mineralogist finds the most beautiful little crystals of limpid topaz. With these there have lately been detected certain oblique crystals of an orange-coloured mineral, which Professor Brush names after the locality.‡ The following is the general formula of *Durangite,* where the protoxides are soda and manganous oxide, whilst the sesquioxides are alumina and ferric oxide: $\{\frac{1}{4}(3\,RO) + \frac{3}{4}(R_2\,O_3)\}\,As\,O_5$. Fluorine is also present in this mineral, but its quantity has not been determined. It is said that Durangite is the only native "fluo-arsenate" which has hitherto been observed.

Professor Brush has also lately published the analysis of a

* Silliman's 'American Journal of Science,' July, 1869, p. 85.
† Ibid., p. 17. ‡ Ibid., Sept., 1869, p. 179.

meteoric stone which fell near Frankfort, in Franklin Co., Alabama, on the 5th December, 1868.*

Attention has again been called to the occurrence of pseudomorphs in Bunter sandstone after scalenohedra of calcite.† The discoveries of Dr. Blum, already noticed in this Journal, have been supplemented by those of Dr. Klocke, from which it appears that the pseudomorphs occur in several new localities in the neighbourhood of Heidelberg.

A new mica, related to biotite and phlogopite, has been described by Von Kobell under the name of *Aspidolite*, in allusion to the basal face of the crystals often resembling an oval shield (ἀσπὶς). The crystals are small rhombic prisms, of a dark olive-green colour, and are found in the chlorite of the Zillerthal in Tyrol.‡

So complex is the chemical constitution of that curious mineral, the *Tourmaline*, that Mr. Ruskin not unaptly calls it "more like a mediæval doctor's prescription than the making of a respectable mineral." In spite of its complexity, Rammelsberg has lately succeeded in reducing all his analyses of this substance to the general type of the silicate $R_6\ Si\ O_5$, where R is considered monatomic, and may represent six atoms of any of the monads hydrogen, potassium, sodium, and lithium; or three atoms of the dyads magnesium, calcium, manganese, and oxygen; or two atoms of the triads boron and aluminium.§ All tourmalines fall into two sections—one represented by the general formula $R_3\ Al_2\ B\ Si_2\ O_{10}$, which is, of course, obtained by doubling the molecule above; whilst the second section contains nine of these molecules written thus:—$R_6\ Al_{12}\ B_4\ Si_9\ O_{45}$.

Rammelsberg has also published a chemical note on the constitution of Axinite, and on some native compounds of tantalium and niobium.‖

Some good crystals of *Gadolonite*—the mineral in which yttria was first discovered—have been examined by M. Des Cloiseaux.¶ He finds the crystals from Hitteröe to be doubly refracting, and to contain from 10 to 12 per cent. of glucina; while those from Ytterby are singly refracting, and contain no glucina.

Dr. Sadebeck, of Berlin, whose examination of the crystalline forms of copper-pyrites has already been referred to in this Journal, has lately directed his studies to another common mineral *zinc-blende*, and has produced an elaborate paper on the hemihedral forms of this cubic mineral.**

* Silliman's 'American Journal of Science,' Sept., 1869.
† Leonhard und Bronn's 'Jahrbuch,' No. 6, 1869, p. 714.
‡ 'Sitzungsberichte d. K. bay. Acad. d. Wissenschaften,' 1869.
§ 'Monatsber. d. k. preuss. Ak. d. Wiss.,' 1869, p. 604.
‖ 'Zeitschrift d. deutsch. geol. Gesell.,' No. 3, 1869, pp. 555, 689.
¶ 'Annales de Chimie et de Physique,' Nov., 1869, p. 305.
** 'Zeit. d. d. geol. Gesell.,' 1869, No. 3, p. 620.

Whilst we have no lack of literature on the geology of the volcanic district of Auvergne—of which the excellent works of Scrope and Lecoq may be cited as conspicuous examples—there has hitherto been but little written on the mineralogical, chemical, and microscopic structure of the many and varied rocks of that country. It is true that a few of these rocks have been carefully described in the memoirs of Kosmann and of Zirkel, but it has been left for Dr. Lasaulx, of Bonn, to offer us the results of a systematic course of "Petrographic Studies on the Volcanic Rocks of Auvergne."* The first part only has yet appeared, and this is devoted to a description of certain of the Auvergne lavas, so that we must look to the continuation of the memoir for a notice of the basalts, trachytes, melaphyres, and phonolites of this interesting locality.

10. MINING AND METALLURGY.

Mining.

The completed returns of the mineral produce of the United Kingdom for the year 1868 have been published in the 'Mineral Statistics.' The following are the results:—

	Quantities.	Value.
	Tons.	£
Coal	103,141,157	25,785,289†
Iron Ore	10,169,231	3,196,000
Tin Ore	13,953	770,205
Copper Ore	157,335	642,103
Lead Ore	95,236	1,150,768
Zinc Ore	12,781	39,191
Iron Pyrites (Sulphur Ores)	76,484	53,636
Gold Quartz	1,191	1,000
Arsenic	3,300	9,710
Gossans and Ochres	6,692	6,372
Wolfram	9	67
Fluor Spar	60	42
Manganese	1,700	7,650
Barytes	14,235	8,728
Coprolites	37,500	71,500
Salt	1,513,840	927,227
Clays, *fine* and *fire*	1,012,479	317,770
Earthy Minerals, various (*estimated*)	.. ..	650,000
Total value of the Minerals produced in the United Kingdom		£33,637,558

* Leonhard und Bronn's 'Jahrbuch,' No. vi., 1869, p. 641.

† Calculated at the actual cost of raising, before any charges for movement are added.

METALS OBTAINED FROM THE ORES ENUMERATED.

	Quantities.	Value.
	Tons.	£
Iron, Pig	4,970,206	12,381,280
Tin	9,300	901,400
Copper	9,817	761,602
Lead	71,017	1,378,404
Zinc	3,713	75,435
	Ounces.	
Silver	835,542	229,[illegible]3
Gold	1,012	3,522
Other Metals (*estimated*)	.. ..	5,000
Total value of Metals produced	.. ..	£15,736,416

ABSOLUTE TOTAL VALUE of the METAL and COAL, with other MINERALS (not including Slates, Lime, Building Stones, or Common Clays), produced in 1868.

	£
Value of the Metals produced from the Mines of the United Kingdom	15,736,416
Value of COAL	25,785,289
Other Minerals, not smelted, including Salt, Barytes, &c., &c.	2,003,819
	£43,525,524

For two years the sad depression of Cornish mining has been the reiterated complaint. This happily has given place to great activity. The tin mines of Cornwall were never producing more tin than at present, and the prices are such as enable most of the mines to give a good dividend, after paying all the working expenses. The long celebrated Bearhaven mines, in Ireland, which produced (in 1868) 3837 tons of copper ore, are about to change hands, and will for the future be worked by the Mining Company of Ireland.

A variety of experiments have of late years been made in our mines and quarries with explosive compounds of various kinds, with very varied degrees of success. Attention is now called to "Poudre d'ammoniaque," which has created quite a sensation in some of the Continental mines. The following extracts will convey nearly all the information, of value, at present available.

The 'Militäi-Wochenr-Blatt,' of Berlin, says:—"Some time ago the proprietors of the powder manufactory of Nora-Gyttorp took out a patent in Sweden for the invention of the 'poudre d'ammoniaque,' a substance only employed hitherto in a few mining districts, and which seems to be completely unknown elsewhere. Its explosive power may be compared to that of nitro-glycerine, and, consequently, surpasses that of dynamite. It will not explode with a flame or with sparks, but explodes by a powerful blow with a hammer. Chambers charged with this powder have been burst by means of a cartouche of ordinary powder. One of the useful and

important properties of this new powder is that it does not require to be heated in cold weather, whilst it is necessary first to heat nitro-glycerine and dynamite, which operation has caused many accidents. According to the information we have received, the "poudre d'ammoniaque" was invented by Norbin, the chemist. The 'Journal of German Public Works' contains extracts from the report of the Prussian architect, Steenke, amongst which are the following remarks concerning poudre d'ammoniaque:—"Experiments have been made by attaching a lamp to a pendulum, and causing it to oscillate. Powder, gun-cotton, nitro-glycerine, and dynamite ignited the moment the flame passed beneath them, but poudre d'ammoniaque only commenced to burn when the flame had touched it twenty times.

"Making experiments to ascertain the pressure requisite to explode it, it was found that, with the instrument employed, explosion followed when the weight descended from 4·5 ft. to 5·5 ft. with powder, 1·6 ft. to 2·25 ft. with nitro-glycerine, 3 ft. to 3·3 ft. with dynamite, and from 13·125 ft. to 14·2 ft. with poudre d'ammoniaque."

The production of gold in Australasia, according to the quarterly returns issued by Mr. R. Brough Smyth for Victoria, and the reports from other quarters, continues to be almost as large as ever.

The quantity of gold exported from Victoria to the 10th of September was 1,145,170 ounces, of which 154,075 ounces were from New Zealand. Very remarkable things are said of the gold fields of the latter place. Some of the quartz, broken from the reefs, or veins, have yielded in recent crushings 30 per cent. of gold. Mr. R. Brough Smyth's book on gold mining will be noticed hereafter.

The want of scientific knowledge amongst our miners is shown in a curious way by some statements which have lately appeared in 'The Mining Journal' on "The Prosperity of Mexico." The "Correspondent" informs us that some curious stones have been discovered at Tula del Hidalgo, "which present a great variety of appearances, and each face has received, and is constantly receiving, *the landscape in front of it, by means of a colour so perfect, that* I believe that art itself cannot produce such relative exactness." Again, we are told, "The faces which begin to receive the first impressions only present the images of the nearest trees with a wonderful perfection and beauty; those that have been in one position for a long time without variation present the complete landscape within the visible horizon, and even the most distant mountains by which it is limited." We perceive in this description a great want of the habit of observation, and a considerable display of "Our Correspondent's" fancy. It will be evident to every one, possessing the slightest knowledge of Mineralogy, that the stones

so vividly described are only examples of that mimic vegetation often so beautifully displayed in stones by the oxide of manganese. Those arborescent forms and shaded outlines will be familiar to many who have visited the heights of Clifton, where the "landscape marble," as it is called, is nicely polished and sold to the many visitors to that delightful locality.

'La Houille,' a French journal devoted to the colliery interests of France is, from, the excellence of many of the articles contained in it, commanding a considerable amount of attention. It has recently given some notices of experiments made by MM. Rouille and Co., on producing a light for mines by atmospheric air, impregnated with petroleum vapour by being passed through the more volatile of the coal-shale oils, or other hydro-carbons. We refer to this only to condemn it. In the first place, the introduction of volatile hydro-carbon vapour into a coal mine is only adding another to the many dangers by which the coal miner is surrounded; and in the second place, the process has been long known, often tried, and it has always failed; because the vapour of the petroleum is speedily deposited from the air, and at a comparatively short distance from the reservoir the air ceases to be inflammable.

Our 'Colliery Guardian' calls attention to the "Lighting of Mines" with common gas, by an apparatus devised by Messrs. Church and Co. We are told that the light is produced by the combustion of a mixture of ordinary carburetted hydrogen gas with atmospheric air in certain proportions, and that from the manner in which the combined fluids are consumed *no flame is produced.* We have not seen this lamp. We do not know how the mixture of air and gas is burnt; we presume from the description given that we have a modification of the well-known Oxyhydrogen Lamp—something of either the Bude-light, or the Drummond-light type. This, however, we do know, that the statement that "no flame is produced" is one which cannot be maintained; and while it tends to deceive those who are not familiar with the laws of combustion, it may prove highly dangerous, by leading the unwary to make experiments in explosive atmospheres, under the idea that where there is no flame there can be no ignition of the surrounding gases. That the flame may not have the character of the ordinary flame of a gas-burner may be true; but the very description given proves that a flame of great intensity is produced by the combustion of the mixed gases.

At the Hayle Foundry, in Cornwall, there have been some experimental trials of a system of pneumatic stamps, which have been witnessed by a large number of practical miners, who are most favourably impressed with the results. The following brief description will, we believe, convey a sufficiently clear idea of the general principles of this machine:—

The battery with which the experiment was tried consisted of six heads, all working in one coffer, contained in a strong cast-iron framing; the crank-axle running in two plummer-blocks, carried on top of side frames, which are 62 inches apart; and the height from ground to centre of axle, 110 inches; the total weight, including everything, 8½ tons. The difficulty to overcome was to give a long and variable stroke of head, with a short and constant throw of crank; this, however, has been accomplished, as with forging hammers, in the following manner:—The upper end of the cylinder is bored, to receive the piston, to a depth of 14 inches; the piston-rod plays air-tight through the cylinder cover, which is screwed metal to metal on the cylinder. The working barrel of cylinder is pierced with two sets of small holes, for the ingress and egress of air, discharging the air behind the piston after it has been once used as an elastic cushion. Suppose the head to be set in motion with the crank in a horizontal position, the piston being in the middle, vertically of the working barrel of cylinder, and midway between the two sets of air-holes referred to. As the crank and attached piston rise, the air is compressed between the piston and cylinder cover, and the cylinder, with stamp-head attached, is forced upwards. When in rapid motion, the elasticity of the compressed air between the piston and cover flings the cylinder, with head, some inches above the range, due to the motion of the crank; on the descent of the piston below the bottom set of holes in the cylinder, the air is compressed in a similar manner, and the cylinder is forced down by the compressed air between the piston and cylinder bottom, until the stamp-head strikes the ore in a coffer-trough; thus, whether the quantity of ore be large or small, the blow is always effective.

At the last meeting of the Midland Institute of Mining Engineers, a discussion took place on the paper read by Mr. A. Lupton, in August last, "On the Use of Hydraulic Machines for Breaking down Coal:"—

On first introducing the subject, Mr. Lupton, with the aid of a number of diagrams, gave the results of several experiments which he made for the purpose of testing the value of the hydraulic machines, including those of Mr. Grafton Jones, Mr. Bidder, and Mr. Chubb. The machine of Mr. Grafton Jones, the principle of which consists in driving a wedge by means of a hydraulic press between two blocks of steel which are rendered incapable of any but lateral movement, by tension-bars connecting them with the press, was tested at the Shipley Colliery, in Derbyshire, where the bed of coal is worked on the long wall system in banks from 80 to 100 yards in length, the coal being 4 ft. 7 in. thick. As much work could be done by it and two men, Mr. Lupton said, in from two to three hours, and as much coal got, as would take two men by the ordinary method from one-and-a-half to two days.

Mr. Bidder's machine was capable of giving any degree of expansion, and, in many instances, is similar to Mr. Jones's, as is also that of Mr. Chubb. The discussion on the paper was a very interesting one, and was taken part in by most of the members present. The great object in introducing such machines for getting coal in mines was stated to be, according to the views of those present, the getting of a maximum quantity of large coal at a minimum cost, and, by doing away with gunpowder, to ensure the greater safety of the workmen. Such being the case, it was considered that every encouragement should be given to the inventors of mechanical power having for its object the getting of coal. The impression with regard to the machines noticed in the paper read was that they were as yet incomplete, but were capable of improvement to an extent at least making their use desirable in many collieries instead of gunpowder, and for producing a larger coal generally.

Metallurgy.

The only metallurgical process which has claimed any special attention during the quarter is the following:—

The Removal of Silicon from Pig-Iron was the subject of an interesting paper read before the Iron and Steel Institute at a recent meeting by Mr. J. Palmer Budd, of Ystalyfera. This process was witnessed in operation by many of the members at the works of Messrs. Bolckow and Vaughan, during the meeting of the Institute at Middleborough. It is claimed for the process that it desiliconises the iron, as tapped from the blast-furnaces, without wasting the iron, and without any extra expense, whatever, beyond the usual cost of the pig; that, in fact, it was more economical to make than pig-iron. Mr. Budd's mode of proceeding is to place a series of iron moulds, similar to those used, before a refinery, as near as convenient to the top hole of the blast-furnace. A paste is made by moistening with water, soft hæmatite ore, which, if gritty, is previously ground, and a bucketful, containing about 60lbs., is thrown into the mould in a semi-liquid state, and spread evenly on the bottom and sides. The mould being quite hot from the previous casting, dries the paste which adheres to the bottom. As much iron as is required from the blast-furnace is then allowed to run over and fill the moulds to the depth of from three-and-a-half to four inches. A great ebullition takes place, jets of flame, of a particularly white colour, burn on the surface, which is assumed to be the combustion of silicon in the oxygen liberated from the hæmatite. It has been proved by repeated analysis that whilst the silicon was 1·00 per cent. in the white cast-iron, it is reduced by this simple process to 0·200 or 0·300 per cent., or from one per cent. to $\frac{1}{500}$th. A cinder is thrown up containing

silica, some phosphorus and sulphur. The carbon is hardly at all removed. The appearance of the iron after the process is that of refined metal. The cost of the process is *nil*, as the iron contained in the hæmatite is reduced, and adheres as cast-iron to the bottom of the iron in the mould. There is no sand or coke-dust used, and the refined iron goes clean into the puddling-furnace. The yield in puddling is that of refined iron, about 21 cwt. to the ton of puddled bars. The puddlers like to have one or two pigs of white iron with the metal so refined, as they say it works more liquory, showing that when the silicon remaining is only 0·200 or 0·300 per cent. the charge does not possess the necessary fluidity. The puddling furnace keeps longer in repair, no other fettling is used than hammer-slag, and the former allowance of shearings to make scrap-balls has been discontinued. The men do more regular work, and, like the refined iron, the yields are larger. The puddled iron is of an improved quality, and much liked in the rail mills. A second process is the same in every respect as the first, only that $\frac{3}{8}$ths by weight, and half by bulk, of nitrate of soda is mixed with the hæmatite ore, which is formed into a paste and applied in the same way. With this mixture the ebullition is greater, the flame is of a yellowish colour, showing the ignition of some of the soda. The cinder is thrown up and out of the iron, over which it forms a crust, which can be separated when cold. The iron has a cellular and honeycombed fracture, like metal much overblown. The scoriæ contain sulphur, phosphorus, silica, and soda. The iron works drier and cleaner, and to a better yield than that made by the first process, but should have about one-third of grey pig added to make a very clean and tough iron. The only cost of the process is the nitrate of soda, which in the proportion named comes to about 4*s*. a ton at its present high price.

11. PHYSICS.

Light.—The Rev. Father Secchi has published an account of the spectrum of the planet Neptune; he first refers briefly to his former observations of the spectrum exhibited by Uranus, and then states that the spectrum of Neptune consists chiefly of three lines, or bands, placed near the green line, and that its light is entirely devoid of red; this is confirmed by the colour exhibited by the planet when seen through a telescope, which is a sea-green.

M. Bontemps, the managing director of the celebrated crystal glass works of Choisy-le-Roi, states, in his observations on the colouration of glass under the influence of direct sunlight, that he was led to the following results:—Within three months after

having been exposed to sunlight, the best and whitest glass made at St. Gobain is turned very distinctly yellow; extra white glass (of a peculiar mode of manufacture) becomes even more yellow, and gradually assumes a colour known as *pelure d'oignon;* glass containing 5 per cent. of litharge is also affected, but far less perceptibly; crystal glass, made with carbonate of potassa (the other varieties referred to contain carbonate of soda), litharge, and silica, is not at all affected; English plate-glass, made by the British Plate-Glass Company, and exhibiting a distinctly azure-blue tinge, remains also unaffected. The author attributes this colouration, which begins with yellow and gradually turns to violet, to the oxidizing effects of the sun's rays upon the protoxides of iron and manganese contained in glass.

A solution of iodide of potassium is, even when kept in well-closed bottles, slowly decomposed by the action of daylight, and assumes a somewhat yellowish tinge due to free iodine. M. Loew filled a number of glass tubes for about from one-half to three-fourths of their capacity, with a solution of iodine of potassium, and, after having sealed these tubes, exposed them to direct sunlight. Another set of tubes were likewise filled with the same solution, but all air was expelled, and the tubes sealed during and after the solution had been boiling for a considerable time. These tubes were also exposed to the action of direct sunlight; after three or four months' exposure the tubes and contents were examined, those wherein no air at all was left were found to be perfectly colourless, no decomposition of the contents having taken place. As regards the other tubes, the following results are noticed:—(1) Under the influence of light, the oxygen of the air decomposes iodide of potassium, iodine in small quantity is set free, while hydrate of potassa is found in the liquid. (2) This decomposition is limited, and does not even, when a large quantity of oxygen is present, increase, because a portion of the iodine set free enters again into combination with the caustic potassa set free, forming iodide of potassium and iodate of potassa. (3) The testing for ozone by means of a solution of iodide of potassium and starch (or paper prepared therewith) is of no value whatever, unless care has been taken to exclude direct sunlight.

HEAT.—M. Dufour recommends the following process for demonstrating that the flame of a candle is formed of a hollow cone, luminous on the outside only, and dark in the interior. A caoutchouc tube has, at one of its extremities, a gas jet with an almost semicircular slit of .04 metre in depth. The other end of the tube communicates with a reservoir of water placed at a convenient height. Upon a suitable pressure, the water flows out by

the slit in the jet, producing a clear sheet. The slit is placed in such a manner that the sheet presents a horizontal surface, and this will easily cut the flame of a candle, showing a perfect section. The hot gases and carbonaceous particles are carried off by the water. On placing the eye above the hollow cone, the luminous wall, &c., can be distinctly seen. Sections may easily be made near the wick or near the point; nothing hinders observation, which may be prolonged at pleasure, and a lens may be used if desired. If a current of air be caused to come out of the slit by bellows, an invisible sheet of air is formed which is also very convenient for making a section of flame. Close observation is quite possible, for the aërial current prevents the heated gases from reaching the eyes, and a lens may be used as in the former case. The flame forms a cone, whose luminous walls are extremely thin, and their size can be plainly seen. A platinum-wire may be introduced across the section; and on being plunged as far as the wick it will remain unreddened in the dark interior of the cone. If a jet of gas produced by a fishtail burner be cut, the luminous fan will be found to consist of two brilliant blades, between which there is a narrow obscure space. The blades are at a greater distance apart, and the dark space is wider towards the end of the fantails; M. Dufour suggests that this method might be of service in the chemical analysis of flames.

Mr. Spence has made public an apparent paradox in the science of heat, whereby he is enabled to raise a higher temperature in certain solutions, by steam of 212° Fahr. He selected a solution of a salt (nitrate of soda) having a high boiling-point—about 250° F. The nitrate of soda was placed in a vessel surrounded by a jacket; steam was let into the intervening space, until a temderature of nearly 212° F. was obtained; the steam was then shut off, and an open pipe immersed in the solution, and steam from the same source was thrown directly into the liquor; in a few seconds the thermometer slowly, but steadily, moved, and minute after minute progressed, until it touched 250° F. This unexpected fact has become to the author of immense practical value. As a corroboration of the theory which seems to explain the apparent paradox, the author finds that the temperatures of his solutions are in the exact ratios of their specific gravities, and have no connection with the temperature of the steam, which never exceeds 212° F.. The greater the specific gravity of his solutions, the higher the boiling-point; and therefore, whatever the boiling-point of the solution in water of any salt, to that point, or nearly, will steam of 212° F. raise it.

The annoyance which arises from the bumping of certain liquids when submitted to distillation or boiling has often attracted the

attention of chemists, and various means have been proposed for its prevention. Dr. Hugo Müller, F.R.S., has described a ready means for overcoming this annoyance. In cases where the introduction of any foreign matter into the liquid about to be distilled is undesirable, he indroduces through the cork in the tubulus of the retort a glass tube, which is drawn out to a long capillary tube, and pressed tightly to the bottom of the retort. The upper end of the glass tube is connected by means of an india-rubber tube, with a generator of carbonic acid or hydrogen, or a gas-holder containing air; and whilst the distillation is going on, one of these gases is passed in a slow but continuous current through the liquid. Under these conditions all bumping is avoided, and the distillation proceeds with the utmost facility. For ordinary purposes, however, it is still more convenient to introduce into the liquid about to be distilled a small fragment of sodium amalgam, or, in cases where the liquid is acid, a small piece of sodium-tin. Methylic alcohol is well known to be one of the most difficult liquids to distil, yet on the introduction of a minute piece of sodium amalgam or sodium tin it can be distilled without the slightest inconvenience. The action of sodium amalgam and sodium-tin is due to a minute but continuous disengagement of hydrogen taking place during the process of distillation.

Dr. Hofmann has described an ingenious experiment to show that a body really increases in weight during combustion. A small horse-shoe magnet is hung up at the beam of a balance, sufficiently sensitive to turn with centigrammes; the poles of the magnet are immersed for a moment in levigated iron, when a beard of small particles of iron adheres to the poles; by means of proper weights placed on the scale-pan at the other end of the beam the equilibrium is restored. This having been done, the finely-divided iron is kindled by approaching to it the flame of a Bunsen gas-burner, and continues to burn. While burning, it will be seen that the arm of the balance on which the magnet is suspended considerably deviates from the horizontal position, thus indicating an increase of weight on the side where the experiment is going on. This experiment succeeds best with a magnet of moderate dimensions. The horse-shoe magnet applied in this instance weighed without its armature 210 grms., and can bear a load of 12·5 grms. of iron. When this is altogether converted in magnetic oxide by combustion the increase in weight will be about 4·7 grms.

Dr. Seelhorst has repeated Barrett's well-known experiments of holding in the flame of burning hydrogen gas very well-cleaned glass rods, metals recently cleaned by filing them just previous to the holding in the flame, and has observed the same blue colouration as Mr. Barrett did. But the author is not inclined to ascribe

this colouration to the effect of sulphur, which should be so generally spread about in the shape of some sulphate as to produce this colouration. The author, though abstaining from stating any precise cause at all, inclines to the belief that the cooling effect of the cold body held in the flame has something to do with this phenomenon. Perfectly pure hydrogen, burning from a platinum burner, as well as from iron or glass burners, exhibited the phenomenon, when cold bodies, just after having been cleaned by scraping or filing, were held in that flame.

According to M. Baille the moon's surface emits as much heat as a cube filled with water, covered with lamp-black, having a surface of 6·5 square centims., and placed at a distance of 35 metres from the thermo-electric measuring apparatus employed by the author for his experiments.

In a paper "On the Reflexion of Heat on the Surface of Fluor Spar and other Substances," by M. Magnus, we learn that the following substances reflect at an angle of 45° the undermentioned quantities of heat:—silver, between 83 and 90 per cent.; glass, between 6 and 14 per cent.; rock-salt, between 5 and 12 per cent.; fluor spar, between 6 and 10 per cent. The same author finds that different bodies heated to 150° emit different kinds of heat; some substances only emit one kind of heat, others, again, various kinds. Pure rock-salt is mono-thermic, sylvine (chloride of potassium) behaves in a similar manner.

M. Delaurier proposes for concentrating and utilizing the sun's rays, a truncated cone, open at both ends and lined inside with polished silver, the sun's rays being admitted by the largest opening. Since the angle of reflexion is equal to the angle of incidence, all direct or reflected rays will be united at the narrower end of the cone. It is clear that the greater the length of the cone, the greater will be the concentration of heat. The author enters into a discussion on the advantage of this contrivance over the use of lenses and mirrors, and he very enthusiastically surmises that the heat of the sun's rays may be so concentrated as to serve for various purposes instead of the combustion of fuel, especially in countries where, as in Algeria, the heat and splendour of the sun are more permanently felt than it is in our climate.

Electricity.—Our limited space prevents us from doing more than allude to one or two novelties in this science. Dr. Runspaden has published a monograph on a subject first observed by Professor Wöhler, that when water acidified with sulphuric acid is decomposed by a galvanic current, and silver is used as electrodes, peroxide of silver is deposited on the anode, and metallic silver on the cathode. The two main questions answered by the author by a series of

experiments are, What is the cause of the formation of peroxide of silver on the positive pole, and by what means does the metallic silver find its way from the positive to the negative pole? In an appendix, the author informs us that there is an error in all works on physics, *viz.* the statement that gold (pure, of course) and platinum are the only two metals which are not oxidized at the positive pole, when serving as electrodes. The author finds, and has confirmed by experiments carefully conducted, so as to exclude any source of error, that gold itself is oxidized to a very considerable extent, and that during such experiments as those alluded to, there is formed a definite oxide,—$Au_2 O_3 3H_2O$; containing gold, 79·47 per cent.; oxygen, 9·62 per cent.; water, 10·91 per cent.

A mode has been devised for depositing copper, silver, or gold by the electric process upon paper or any other fibrous material. This is accomplished by first rendering the paper a good conductor of electricity, without coating it with any material which will peel off. One of the best methods is to take a solution of nitrate of silver, pour in liquid ammonia till the precipitate formed at first is entirely dissolved again; then place the paper, silk, or muslin, for one or two hours in this solution. After taking it out and drying well, it is exposed to a current of hydrogen gas, by which operation the silver is reduced to a metallic state, and the material becomes so good a conductor of electricity, that it may be electro-plated with copper, silver, or gold in the usual manner. Material prepared in this manner may be employed for various useful and ornamental purposes.

12. ZOOLOGY—ANIMAL PHYSIOLOGY AND MORPHOLOGY.

Physiology.

The Origin of the Fibrin of the Blood.—Dr. Heynsius in the course of a series of investigations on the albuminoids of the blood, endeavoured to determine whether any of the constituents of the blood corpuscle contribute to the formation of fibrin. He finds that the quantity of fibrin obtained from the same blood by the same treatment is somewhat variable, owing to the defectiveness of the method. By whipping the blood, a greater amount of fibrin is obtained than by washing the clot. The addition of phosphate of soda to the blood previous to coagulation, causes great difference in the amount of fibrin. In the plasma of the dog, the quantity of fibrin, or of its parent substances (as taught by Buchanan and Schmidt), is certainly smaller than the quantity of fibrinogenetic

substance and globulin contained in the blood. In chicken's blood the quantity of fibrin obtained is alone much greater than the quantity of fibrinogenetic substance that can be separated from the plasma diluted with a solution of salt of four per cent. Hence it is not possible to doubt that the albuminoid substance of the so-called stroma of the blood corpuscles contributes to the formation of fibrin. These observations of Dr. Heynsius are of very great value, as they tend further to explain the mysterious process of coagulation of the blood, for although the ammonia theory is abandoned, and Schmidt's view of a fibrinogenetic material in the plasma, and a fibrinoplastic one in the corpuscles, has been taught as the best explanation which could be offered of the phenomenon, yet further details were and are still wanting. It appears now that the corpuscles can furnish fibrinogenetic as well as fibrinoplastic substance.

Whence comes the free Hydrochloric Acid in the Stomach?—Acid phosphates reacting on alkaline chlorides produce free hydrochloric acid. In the capillaries of the stomach, distended by engorgement, acid phosphates are believed by Professor Horsford, of Cambridge, Mass., to be formed, and thus the free hydrochloric acid produced. By dialytic action the hydrochloric acid is rapidly separated from the inner tissue where it is formed, and coming in contact with the epithelial cells of the gastric tubules, bursts and dissolves some of them, thus forming pepsine, which, together with the acid, some phosphates and chlorides, escapes into the stomach to act in the liquefaction of food.

Development of Gas in Protoplasm.—Dr. Th. Engelmann has observed in *Arcella*, a minute protozoon like an *Amœba* with a shell, a periodical development of gas. Dr. Engelmann made his observations on specimens confined in a gas chamber, and describes minutely how gradually in the protoplasmic hyaline substance of the animalcule, black points arise, which as gradually coalesce, forming a distinct air-bubble. This gas can after a time be absorbed again, and reasons are given for believing that a sort of volition is exercised by the *Arcellæ* in the secretion and absorption of the gas which they use in the manner of a float or air-bladder. The air-bubbles are not connected with the contractile vacuoles or with the nuclei. The air-bubbles, it is important to observe, do not occur in the non-granular protoplasm of the pseudopodia, but in the granular substance, and are not spherical but of an irregular form, which, as Dr. Engelmann observes, proves that the protoplasm is not in the condition of aggregation of a fluid. The chemical composition of the gas thus so remarkably developed by the *Arcellæ* was not determined, nor the mechanism (if any exist) of the formation and disappearance of the air-bubbles. The discovery is of importance from two points of view: in the first place, for the development of

gas in protoplasm as a physiological phenomenon; in the second place, for the supposed voluntary nature of this development, of which this exceedingly simple organism makes use for the purpose of locomotion. In the 'Cambridge Journal of Anatomy' this paper is noticed very fully by Dr. Moore.

Starch in Muscles.—Nasse has found starch in the muscles, of which he considers it a normal constituent, and believes it to be consumed in muscular action, forming a part of the fuel with which our muscular engines are fed. It is not many years since starch was regarded as a peculiarly vegetable product, and even now it seems difficult to persuade some people that it is not. Bernard's discovery of glycogen, or liver-starch, is, however, sufficiently well known, and so-called "annyloid substance" has been found in many other organs. The starch in muscle is probably connected with the sugar there found, and some time since shown to be connected with muscular activity by Ranke.

The Endings of Nerves in the Liver.—Professor Pflüger, of Bonn, continues his valuable researches on the terminations of nerves in the various glands of the body. By the use of hyperosmic acid applied in a method peculiar to himself, Pflüger has shown that the nerves to the salivary and pancreatic glands end in or as parts of the substance of the secreting cells of those glands. He now shows, in the last number of his 'Archiv,' that this method of termination is found also in the liver. His observations on the structure of the liver generally are confirmatory of Dr. Beale's views, in opposition to some recent German investigators. He speaks of the hepatic cell as a nucleated swelling of the axis cylinder of a nerve. Hence the influence of the nervous system on the secretion of bile, as seen in the well-known influence of mental affections upon it, is rendered intelligible. So, too, with regard to other glands, for Pflüger holds that it is impossible to understand the action of a nerve upon a secreting gland, or upon any other active structure, without the supposition of a continuity of structure between the two, and this continuity he has now demonstrated in the more important glands.

The Secretory Nerve of the Parotid Gland.—Professor Eckhard has, in a recently published essay, given an account of a series of careful researches on the nerves which directly stimulate the secretion of the parotid gland. By various arguments he is led finally to the conclusion, that in dogs the secretory nerve of the parotid is the tympanic branch of the glosso-pharyngeal nerve.

Morphology.

Cuckoo's Eggs.—Professor Alfred Newton, of Cambridge, in a recent number of 'Nature' advocates and endeavours to explain Baldamus' views with regard to the eggs of the cuckoo. Baldamus maintained that the popular assertion (popular where?) that the cuckoo lays an egg which varies somewhat in colour according to the nest in which it is deposited,—being modified according to the case, so as to imitate the appearance of the eggs belonging to the nest—is right. This, Professor Newton accepts as a fact, having seen Dr. Baldamus' specimens, and he endeavours to explain this modification of the egg which must otherwise be supposed to be a voluntary act of the bird, by an appeal to the Darwinian theory.

Professor Newton supposes that of a number of eggs laid by cuckoos in the nests of a given species of bird, those eggs would be most likely to come to maturity which, *cæteris paribus*, had the strongest resemblance to the egg of the given species. He further supposes that the offspring would inherit a tendency to lay in the nest of the same species which its parent had imposed upon, and thus there would be established a race of cuckoos infesting the nest of species A, another race infesting B, and so on, each of which races must tend to imitate closely more and more the eggs of the infested species. Mr. Sterland objects to this, that in England no such variety in cuckoos' eggs as that described by Baldamus is seen, and that the hedge-sparrow's blue eggs are those most commonly associated with the utterly different speckled eggs of the cuckoo. He also maintains that the supposed separate races of cuckoo would not be able to keep unmixed, that they must get interbred, but he forgets that the females could only be crossed by males, who may be unable to transmit or affect peculiarities belonging to the females who were their progenitors or happen to be their consorts.

The Kinship of the Vertebrates and the Ascidian Molluscs.—Kowalevsky, a Russian observer, has made some investigations into the development of Ascidians, which are likely to excite more attention than anything of the kind has for years past. His observations were made two years ago, and were noticed as of importance, first by Ernst Haeckel, of Jena, Darwin's great champion and exponent in Germany. Now Professor Kupffer, of Kiel, confirms Kowalevsky's statements, and more credence and attention will be daily given to them. It has been long known that the larvæ of certain Ascidians, when minute free-swimming creatures, have somewhat the aspect of tadpoles, having like them a long swimming tail. This tail has a firm gelatinous rod running along it and projecting into the body of the larva. Now in all vertebrates one of the earliest structures elaborated in the course of development is a long

cartilaginous rod, which runs from the tip of the tail to a point near the middle of the head, and round this, which is called the "notochord," bones and muscles develop. It is however an essential and most important feature in vertebrates, that by the rising-up and closing-in of the walls of the body above this notochord a tube is formed, which becomes the great cerebro-spinal nerve-organ, whilst below this axial rod the viscera and blood-vessels lie in a second tube, formed by the closing-in of the walls of the body below the notochord. Now it is a very remarkable fact that the nervous system in these young Ascidians is seen to lie over the gelatinous rod which runs along their tails, whilst the heart and viscera lie below it. The mode of formation of the nerve-system as described by Kowalevsky and Kupffer is the same as that seen in Vertebrata, that is, there is a rising-up of the embryonic walls to enclose a cavity, and though this part of the observations is not quite definite, it certainly appears as a long fusiform vesicle, which stretches its length through the embryonic Ascidian, being connected with a much larger vesicle anteriorily. It does not seem improbable to the believers in evolution that these structures in the embryo Ascidian represent some distant connection in development between them and the Vertebrata. More has to be looked for on this matter, and it is a subject for congratulation that the same brilliant observer, M. Kowalevsky, who has drawn attention to these facts as to Ascidians, should in the same year have furnished us with a most valuable account of the development of the lowest vertebrate, viz. *Amphioxus*, the history of which was previously unknown.

The Significance of Cranial Characters in Man.—Professor John Cleland (spoken of by mistake in our report of the British Association Meeting as Professor McClellan) has communicated to the Royal Society a paper in which he gives an account of some careful investigations into the cranial measurements of various races, and criticizes the various methods of craniometry in use—pointing out what facts of growth and relation of parts the observed measurements really indicate. He observes that if the terms dolichocephalic and brachycephalic are to retain any scientific value, as applied to skulls, the "cephalic index" (that is, the breadth in terms of the length which is called 100) must not be depended on. Other points of importance, as pointed out by Retzius, must be attended to. According to Dr. Cleland, the relation of the height to length of a skull is of great importance. There is no foundation whatever for the supposition, which is a wide-spread one, that the lower races of humanity have the forehead less developed than the more civilized nations; neither is it the case that the forehead slopes more backwards on the floor of the anterior part of the brain-case in them than it does in others.

Diatom Markings and Podura-scale Markings.—The Rev. J. B. Reade, by the use of a very admirable reflecting medium, *viz.* a prism—constructed by Mr. Highley, of London—has been able to demonstrate satisfactorily that the so-called hexagonal markings of diatoms are, as Mr. Wenham had previously urged from investigating splintered bits of diatom-valves, simply hemispherical close-set tubercles. Dr. Royston Pigott, of Halifax, had, curiously enough a little before Mr. Reade, come to the conclusion that the well-known markings of the Podura-scale are caused by a series of spherical "beads" placed in the substance of the scale, which so act on the light as to produce the effect known to all microscopists. Dr. Royston Pigott has examined the subject with exceeding care, having had a $\frac{1}{16}$th especially constructed for his use, and availing himself of great mathematical knowledge in discussing the optical problems involved.

Literature.—The reader is reminded of the 'Record of Zoological Literature', part of which is now ready, and which to increase its usefulness is now brought out in three separate volumes, so that those interested in a special department may obtain a complete and reliable record of what has been written concerning it during 1868, without being encumbered by other matter.—M. Pollen, with the aid of several illustrious Dutch professors of Natural History, is publishing at Leyden an elaborate work on 'The Fauna of Madagascar and the neighbouring Islands,' where he spent some years exploring and collecting.—A new work by Mr. Darwin, 'On Man,' is stated by 'The Academy' to be in preparation.

Memorial to Dr. Sharpey.—A physiological laboratory and scholarship and a portrait and bust of Dr. Sharpey are now being subscribed for by old and present students of University College, London, and by others interested in physiological research, and who value the teaching and influence of Dr. Sharpey in this country; the object of the subscription being to do honour to Dr. Sharpey, and to form a species of testimonial or memorial to him. There is not in England a single laboratory of experimental physiology properly worked and used for the education of students. It is to be hoped that the proposed Sharpey laboratory may form an example to be followed elsewhere. A distinguished German physiologist lately observed upon the strangeness of the fact, that in England we produce absolutely no physiologists in the strict sense. This may be due to the want of laboratories, which are provided by the State in other countries.

Quarterly List of Publications received for Review.

1. The Life and Letters of Faraday. By Dr. Bence Jones, Secretary of the Royal Institution. 2 vols. *Illustrated.*
Longmans, Green, & Co.
2. Elements of Chemistry: Theoretical and Practical. By William Allen Miller, M.D., L.L.D., V.P.R.S. Fourth Edition, with Additions. Part III., Organic Chemistry.
Longmans, Green, & Co.
3. Exercises in Practical Chemistry. By A. G. Vernon Harcourt, M.A., F.R.S., and H. G. Madan, M.A., F.C.S. Series I. Qualitative Exercises. *Clarendon Press.*
4. Essays on Physiological Subjects. By Gilbert W. Child, M.A., F.L.S., &c. Second Edition, with Additions.
Longmans, Green, & Co.
5. Twelve Lectures on Primitive Civilizations and their Physical Conditions. By John P. Mahaffy, A.M. *Longmans & Co.*
6. The Science of Arithmetic: a Systematic Course of Numerical Reasoning and Computation. By James Cornewell, Ph.D., and J. G. Fitch, M.A. *Simpkin, Marshall, & Co*
7. The School Arithmetic. By James Cornewell, Ph.D., and J. G. Fitch, M.A. *Simpkin, Marshall, & Co.*
8. Studies of the Land and Tenantry of Ireland. By B. Samuelson, M.P. *Longmans, Green, & Co.*
9. A Practical Treatise on Metallurgy, adapted from the last German Edition of Professor Kerl's Metallurgy. By William Crookes, F.R.S., &c., and Ernst Röhrig, Ph.D., M.E. Vol. III. Steel, Fuel, Supplements. *With* 145 *Woodcuts.* *Longmans & Co.*
10. Chemistry for Schools. By C. Houghton Gill, Assistant-Examiner in Chemistry at the University of London. *With* 100 *Illustrations.* *James Walton.*
11. Burton-on-Trent. Its History, its Waters, and its Breweries. By William Molyneux, F.G.S. *Trübner & Co.*
12. Index to the Fossil Remains of Aves, Ornithosauria, and Reptilia, from the Secondary System of Strata. Arranged in the Woodwardian Museum, Cambridge. By H. G. Seeley.
Cambridge: Deighton, Bell, & Co.

13. The Rise and Progress of Manufactures and Commerce, and of Civil and Mechanical Engineering in Lancashire and Cheshire. By William Fairbairn, C.E., LL.D., F.R.S. (now Sir William Fairbairn, Bart.).

PAMPHLETS AND PERIODICALS.

Mineral Statistics of the United Kingdom for the Year 1868. By Robert Hunt, F.R.S., Keeper of the Mining Records. (Memoirs of the Geological Survey.) *Longmans.*

The Triassic and Permian Rocks of the Midland Counties of England. By Ed. Hull, M.A., F.R.S. (Memoirs of Geological Survey.)

The Lichen Flora of Greenland. By W. Lauder Lindsay, M.D.

On the Geographical Distribution of Coniferæ and Gnetaceæ. By Robert Brown, F.R.G.S.

Introductory Lecture at the Royal College of Science, Ireland. By Ed. Hull, F.R.S., Director of the Geological Survey of Ireland.

The Land Question in Ireland. By B. B. Stoney, M.B., M.I.C.E.

The Examination of Petroleum and other Mineral Oils according to the Petroleum Act, 1868. By A. Norman Tate.

A Trip to America. By James Howard, M.P., Bedford.

The Alexandra College, Dublin. Programme and Synopsis of Lectures to Ladies. (Three Pamphlets.)

On the Continuity of the Gaseous and Liquid States of Matter. By Thomas Andrews, M.A., F.R.S. Bakerian Lecture.

Methods of Teaching Arithmetic. By J. G. Fitch, M.A. *Stanford.*

Introductory Address delivered at the Royal Infirmary School of Medicine, October 1st, 1869. By A. Davison, M.A., M.D. *Liverpool: Adam Holden.*

The Working Man's School. By W. J. Kennedy, M.A. *Longmans.*

The Popularity of Error and the Unpopularity of Truth. By John Hampden, Esq.

A Brief Paper on the Pathology of Insanity. By R. C. Shettle, M.D., Physician to the Royal Berks Hospital.

The Canadian Naturalist and Geologist. (With the Proceedings of the Natural History Society of Montreal.)

The Liverpool Medical and Surgical Reports. Edited by P. M. Braidwood, M.D., and Reginald Harrison, F.R.C.S.

The Geological Magazine.

The British and Foreign Mechanic.

The Quarterly Journal of Microscopical Science. *J. Churchill & Sons.*

Revue Bibliographique Universelle.

Cosmos.

Journal of Applied Chemistry, published simultaneously in New York, Philadelphia, and Boston.

The American Naturalist.

Van Nostrand's Eclectic Engineering.

Scientific Opinion.

The Gardener's Magazine.

The Civil Service Gazette.

The Westminster Review.

PROCEEDINGS OF LEARNED SOCIETIES, &c.

Öfversigt af Kongl: Vetenskaps-Akademiens Förhandlingar. *Stockholm: Norstedt & Söner.*

The Journal of the Historical and Archæological Association of Ireland.

Journal of the Farmers' Club.

Proceedings of the Royal Society.

" " Royal Astronomical Society.

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L'Ancresse No. 1.

L'Ancresse. No. 2.

JOURNAL OF SCIENCE.

APRIL, 1870.

I. MEGALITHIC STRUCTURES OF THE CHANNEL ISLANDS: THEIR HISTORY AND ANALOGUES.

By Lieut. S. P. Oliver, Roy. Art., F.R.G.S.

The Cromlechs in Jersey and Guernsey and adjacent islands partake of the character of the French *Dolmens* and *Grottes aux Fées*, as well as the *Gangrifter* (gallery-tombs) of the Swedes, the *Jettestuer* (chambered tumuli) of the Danes, and the German *Hünenbetten*.

Our word "cromlech," however, is so often applied to such widely different structures, that there is no wonder if it sometimes misleads foreign archæologists. The cromlech of the English antiquarian is the same as the Welsh and English "*quoit*," such as *Arthur's quoit* or *coetan*, near Criccieth; *Lanyon quoit*, and *Chun qwoit* and others in Cornwall; *Stanton Drew* "*quoit*," in Somersetshire; the *Kitt's Koty* or *Coit*, near Maidstone; and the *Coit-y-enroc*, in Guernsey. Now, we can quite understand what we mean when we use the word cromlech to be identical with all these; but the French archæologist, when he uses the word cromlech, is right only when he applies it to a circle of upright stones, like the Hurlers and the Nine Maidens in Cornwall; thus the bardic circles convey a very different meaning to the Dolmen, or Table of Stone (*Dol* a table, *moen* a stone), when used by our Gallic neighbours.

Professor Sven Nilsson defines the English cromlech as synonymous to the French Dolmen, the Scandinavian *dös*, and the *dyss* of Denmark, consisting of one large block of stone, supported by from three to five stones arranged in a ring, and intended to contain one corpse only,* several of these *dorsar* being sometimes enclosed in circles of raised stones.

Following, however, the nomenclature given by the late Dr. Lukis, we cannot be far wrong in assigning the word cromlech to all elaborate megalithic structures of one or more chambers, in

* Nilsson on 'The Stone Age,' pp. 159.

which category the passage-graves may be included. Nilsson has clearly pointed out how the gallery or half-cross tombs are close imitations, if not actual adaptations, of the original dwelling-houses of the ancient Pre-Celtic Scandinavians, a people not dissimilar in their mode of life to the present Arctic nations of Esquimaux; also how these galleried-huts were but make-shifts in the plains for subterranean caves and grottoes in the mountain region from whence their race originally sprang.

As regards the cromlechs in the Channel Islands, their chief characteristics may be briefly stated as follows:—

(1.) The large western chamber, composed of large, erect, and, at least on the inner side, flat slabs of granite,* from six to eight feet high, arranged in a circular or horse-shoe form, supporting an enormous capstone (the lower side of which is also flat), the largest stone in the whole structure. At the west extremity of this chamber is the largest of the erect slabs, a flat polygonal stone, as broad as it is high, the remaining uprights being generally less broad than they are high. This chamber is sometimes divided into smaller compartments or kists. A good example of these divisions is to be found in the cromlech at Mont Ubé, Jersey, from which, unhappily, the capstones have been removed many years since.

(2.) The covered gallery or passage leading to the great west chamber from the east. The stones forming this, both erect side blocks and granite imposts, being largest at the western end, and diminishing in height, size, and distance apart towards the eastern entrance. This avenue is sometimes so modified as to seem a mere prolongation of the west chamber, the capstones diminishing in regular order from the huge block at the west to the small one at the east, so that the whole structure is bottle-shaped. The gallery is frequently divided by stone partitions, and there are indications of thresholds where doors may have existed.†

(3.) The addition of kists outside the main structure, of a later period; notably conspicuous in the cromlech Dé-hus.

(4.) The structure surrounded with a stone circle, the centre of this circle generally in the western chamber; the circles are of the same dimensions throughout the islands, *viz.* 60 feet. From this circle or peristalith in some cases are traces of serpentine avenues or approaches, probably indicating similar forms to those of Abury. These avenues are seen best at L'Ancresse. At the Pocquelaye Cromlech there are remains of a double stone wall encircling the structure; between these are four small uprights, which seem as though they had formed a portion of a peristalith.‡ The peristalith of the Couperon Cromlech is *oval*.

* Except the Couperon Cromlech, Jersey, which is built of local conglomerate.

† Compare Sir John Lubbock's 'Description of the Danish Tumulus in the Island of Moen,' p. 105 'Pre-historic Times.'

‡ See view in 'Illustrated London News,' January 15th, 1870.

(5.) All the cromlechs were formerly covered with a tumulus of earth; these remain in many instances, at Creux des Fées and Du Thus, but a large proportion have been denuded of their earth-mound either by accident or design, as L'Ancresse, Le Trepied, Mont Ubé, Le Couperon, the Pocquelaye, &c.

These are the chief external characteristics of these stone structures; when we examine their interiors we find the following noteworthy points:—

(1.) Thick layers of limpet shells, forming a hard concrete, through which a pick-axe is forced with difficulty. The solitary exception to this general find is the cromlech of Ville Nouaux, in Jersey, where no limpet shells were found when explored in May, 1869, by the author.

(2.) A vast quantity of human bones, with bones of animals, showing that the structure was used as a catacomb, and that interments had been made for a long period. Pavements of flat sea-worn pebbles, over successive layers of interments, point to the same conclusion. No bones, however, were found at Ville Nouaux.

(3.) The presence of rude pottery and stone implements, and absence of bronze or iron.

(4.) The position of skeletons indicates that they were buried in a sitting posture, similar to those found in the Scandinavian tumuli.

(5.) Absence of any attempt at ornamentation of the stones similar to the engraved rocks of Gavr'Inis. Exception, the cup-markings on the Kistvaen, in centre of L'Ancresse Common.

One curious characteristic of these monuments may be noticed more in Guernsey than in Jersey, *viz.* that the majority of these structures are within sight of one another. Undoubtedly, in primeval times, such monuments were in existence on every headland round the coast; and it is possible that signal fires may have been used in connection with them. Most of these characteristic features are exhibited in the large cromlech on L'Ancresse Common, which stands on an eminence, called by the inhabitants of the Clos du Valle, Mont St. Michel, whilst the structure itself they call *L'Autel des Vardes.* Two photoxylographs are given of this interesting structure from different points of view (see Plate I., Figs. 1 and 2); but although the huge capstones are well shown, and the gradual diminishing of their size towards the east, still no outside view can convey any idea of the size of the chamber and passage beneath, in consequence of the sand and soil being so heaped up around the outside of the structure, that only the tops of the side props are visible. However, at the west end one may stand upright beneath the largest capstone; and when the soil was removed from the floor during the exploration of this cromlech by Mr. Lukis and his sons, the height of the western chamber was

eight feet. The westernmost upright block is almost identical in size and shape with those blocks occupying similar positions in the cromlechs of the Creux des Fées, Mont Ubé, and the Pocquelaye.

On the north side of the L'Ancresse Cromlech, under the largest capstone, an evident disturbance of the pristine condition of the structure has taken place, one of the side blocks having been pushed outwards apparently, and smaller stones added, so as to form a supplementary kist, in which human remains were found, indicating a secondary interment. It would take up too much space to detail the relics found at the excavation of this structure; it is sufficient to mention that they were all attributable to the Stone age, and have been fully described by Mr. Lukis in the Archæologia, and by Messrs. Worsaæ and Thoms.

Divergent from the partially-destroyed circle which surrounds the cromlech are two paved causeways, leading in a winding track to the N.W. and N.E. Lines of Menhirs must probably have been associated with them. We cannot help noticing the similarity of some causeways observed by Capt. Parry in the Calthorp Islands in 1822, in connection with some deserted Esquimaux *stone galleried-huts*, amongst which human skulls, *lapis-ollaris* lamps, and glass beads, were lying about "*as usual.*"

"Leading from the huts towards the highest part of the island was a curious path made by the natives, two feet in width, and formed by removing the stones in places where they were naturally abundant, and where the ground was bare, by placing two regular and parallel rows at that distance apart. The only conjecture we could form respecting the use of this artificial road was that it might be intended for a deer path (those animals preferring a regular or beaten track to any other), by which means the Esquimaux might perhaps kill them from their usual ambush of stones."*

From the hill on which the great cromlech of L'Ancresse stands, other megalithic structures can be seen; for instance, in an eastern direction, and near the foot of the hill, are various blocks of stone, the relics of a cromlech, known from its position by a marshy pond as *La Mare aux mauves*, not far from which again is a portion of a stone circle, and some stone graves of the Bronze period. In the centre of the common is an interesting Kistvaen, consisting of a large oddly-shaped capstone (probably only a portion of the original stone), supported on several props. On one of these blocks are some barely-distinguishable cup-markings;† whether

* Vide Parry's 'Second Voyage,' p. 285.

† Since writing the above, the author has again examined those cup-markings, which, now that the lichens have been cleared out of them, present evident signs of artificial handiwork. They are nine in number, at the side and top edges of the N.E. prop.—S. P. O., February 4, 1870.

natural or artificial is mere conjecture. A Logan or rocking-stone once existed on a natural cropping out of rock to the eastward of L'Ancresse; the site still bears the name of La Rocque Balan.

The cromlech next in importance to that at L'Ancresse, which it rivals in size, is that known by the name of Dé-hus or Du-Thus (Deuce), by some L'Autel du Grand Sarazin (see Plate II., Fig. 1). On examining this structure we see at a glance the large western chamber, with its huge capstone over 16 feet long, and weighing at least 20 tons. The second capstone, that next to the largest, is broken, and the fracture apparently took place during the period of cromlech-builders or their immediate successors, as the larger half of the stone still remaining *in situ* has been propped up by an additional stone pillar. In all there are eight capstones, which, with the side blocks supporting them, diminish gradually in bulk towards the eastern entrance, which is blocked up by a large stone, analogous to the L'Ancresse and other cromlechs. The narrow orientated gallery is conspicuous likewise, whilst the main body of the structure is divided into three chambers. The most noticeable features however, after all, in this cromlech, are the four side chambers, two to the north and two to the south; these are square and polygonal kists, some of which are entered from the eastern gallery, and others distinct, but all adjoining. In the chamber to the north and east were found two skeletons in a kneeling (crouching?) posture, the flat stone which covers the kist nearly touching their skulls. In the chambers to the south were found several layers of interments, the human bones being disposed in groups crosswise, with the skull on the top, indicating the corpses to have been placed in a sitting posture. There were pavements of flat stones between the layers of interments, which resemble exactly similar instances in the West Gothland tombs.*

As at L'Ancresse and in the other cromlechs of the Channel Islands, innumerable quantities of limpet shells were deposited for a depth of two feet throughout the structure, and various vases of ancient pottery-ware were disinterred; they are constructed of extremely coarse clay, worked with the hand, imperfectly baked, and some rudely ornamented, together with stone and bone instruments, clay beads (locally called Roulettes des Fées), amulets, &c.

Not far to the north-west of Dé-hus are vestiges of a kist, the capstones of which were destroyed against the wish, and in the absence, of the proprietor; this monument curiously enough bears the name of *Le Tombeau du Grand Sarazin*, a name in conjunction with a similar appellation given to Dé-hus, significant of the *Iberic* element, distinctly traceable in the ethnology of the Channel Islanders. A Dolmen, or *Trilithon*, consisting of a large capstone

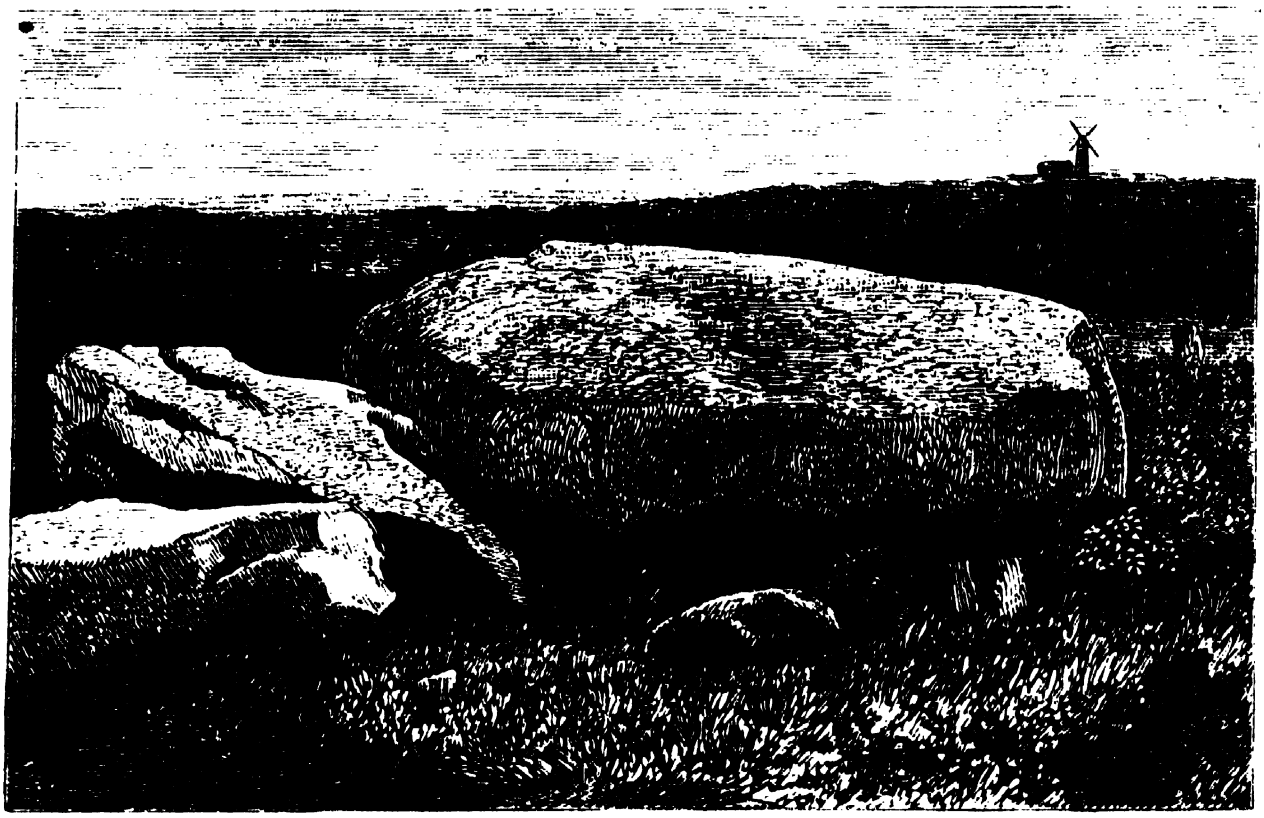
* Nilsson on 'The Stone Age,' p. 149.

13 feet in length, resting on two props, and partly covered by the débris of a neighbouring quarry, still marks the spot where a large cromlech formerly stood in the same parish as the abovementioned remains; the huge western capstone, *now destroyed*, bore the name of *La Roche qui sonne*. An analogous name to this Guernsey Memnon, *La Roque où le Coq chante*, another site in Guernsey, is mentioned by Victor Hugo in his celebrated work, *Les Travailleurs de la Mer*, in which he mentions the popular superstition concerning these remains:—"*Cette pierre est fort à surveiller. On ne sait ce qu'elle fait là. On y entend chanter un coq qu'on ne voit pas, chose extrèmement désagréable. Ensuite il est avéré qu'elle a été mise dans ce courtil par les sarregousets, qui sont la même chose que les sins.*"

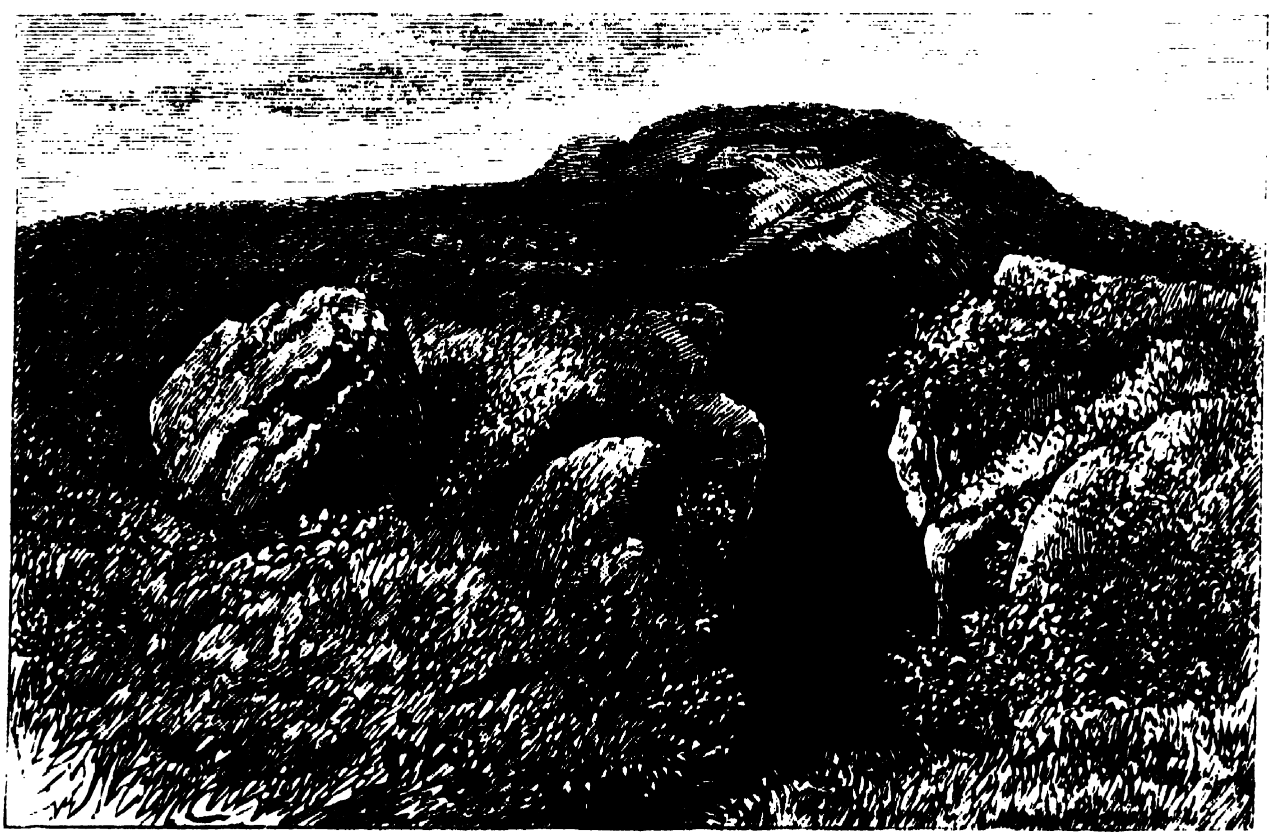
This cromlech is said to have been the largest in the island, and as the greatest part of the structure extended to the westward of the present remains, the largest capstone to the west must have been an enormous block; great superstition, indeed, attached to the broken portions of this structure. The farm-house of Belval close by was partly built of fragments from this cromlech, and shortly after the completion of its building it took fire and was destroyed. A vessel also sailing from St. Sampson's with *macadam*, from the same source, is said to have sunk. When the remaining portions were investigated, the proprietor is said to have looked on the *sacrilegious* proceedings with a terrified countenance, as if expecting that "Satan himself was about to be disinterred."

The fourth capstone at L'Ancresse much resembles the remaining capstone of *La Roche qui sonne* both in size and shape (a triangular prism), but is slightly smaller. The sole remaining impost of one of the Alderney cromlechs, *viz.* that at Tourgis, is in every respect similar also. This leads one to suspect that this stone was the fourth stone of the cromlech, and if so, the "*Roche qui sonne*" Cromlech would have been proportionately larger than the cromlech at L'Ancresse.

The last illustration accurately represents the present condition of a cromlech in the parish of St. Saviour, Guernsey, known by the name of the *Creux des Fées*, and which well exhibits the peculiar features of the French *Grottes des Fées* and *Allées couverts*. The western chamber is still covered in by a great portion of the original superimposed tumulus, and in fact forms a subterranean chamber or grotto, with the narrow passage entrance, now uncovered, but formerly covered with transverse slabs of stone resembling the *gang-graben* of Scandinavia. Only the two largest capstones remain, covering a chamber 21 feet long by 12 feet broad. This chamber has long been used as a cattle stable, and in consequence is not quite so sweet as might be. Here may be observed with advantage the usual method of filling the interstices between the



1.—L'Autel Dé-hus.



2.—Creux des Fées.

larger blocks with smaller stones, to keep out the soil of the surrounding tumulus. The narrow entrance shown well in the accompanying photoxylograph (Fig. 2) is only 2 feet 6 inches broad. The two stones where the threshold formerly was are 4 feet 6 inches in height. The western upright slab is 6 feet in height, and of the same breadth. The plans of all these cromlechs should be compared with one another and those in Jersey; they may be found by those who care to inquire further into their original construction in the 'Journal of the Ethnological Society' for April, 1870, to which the reader is also recommended to refer for details concerning the other cromlechs in Guernsey; for in an article of this description it is impossible to enter into details of the numerous pre-historic remains yet extant in the bailiwick of Guernsey and its dependencies. The chief and most noted may be briefly enumerated as follows—*viz.* Le Trépied Cromlech, the Menhirs of *La Pierre Longue* and *Le Crocq* (La Pierre pointue, La Chaise au Prêtre, and La Rocque Magié have disappeared before the blast of the quarrymen), and the *tumuli* or *Hougues* of *Hatnée* and *Fouqué*. Putting aside the pre-historic remains in Alderney, Herm, and Sark, which fully deserve a paper to themselves, and which all carry out the generic resemblance to the galleried tombs of Scania, in Gothland, it is best to proceed to describe one or two of the principal Jersey cromlechs, in which the characteristics mentioned are fully exemplified. Three views of these remains, *viz.* two cromlechs, those of Mont Ubé and the Pocquelaye, with Le Quesnel Menhir, will be found in a recent number of the 'Illustrated London News,' January 15th, 1870.

The most important of the Jersey cromlechs is undoubtedly that one named the "Pocquelaye," near Gorey Harbour, Jersey; the only visible portion twenty years ago was the largest capstone, the sustaining props and other stones being entirely hidden beneath the remains of the tumulus. About the year 1848 excavations were made by Mr. Fauvel, and it was then discovered that this large stone formed the covering of a chamber of nine side blocks arranged in a horse-shoe form, whilst this chamber was again divided by partition-stones forming a smaller kist, a separate grave as it were, within a tomb. Further excavations were made, and five or six more chambers were discovered to the eastward of the first-mentioned. One chamber alone on the north side had a capstone *in situ;* this capstone was thrown down by the treasure-seeking proprietor, but is now restored as nearly as possible to its original position. Other blocks of stone were also thrown down at the same time, but have been replaced; great doubt unfortunately must always attach to any attempted restorations of such structures. Remains were found, but unfortunately no proper records of their position in the catacomb exist, whilst the pottery, relics, and stone

implements associated with the human skeletons were sold to the British Museum, where they now are.

The narrow eastern gallery is well exhibited in this example, as also the remains of a double circular stone wall not dissimilar to that at L'Ancresse, but if anything of a larger diameter. Four upright stones now standing between these stone walls may have formed a portion of a peristalith, but unhappily there is a want of trustworthy evidence as to their really being *in situ*, as the walls and remains generally have been meddled with to such an extent that it is well-nigh impossible to separate the modern restoration from the original design..

The Couperon Cromlech in the same parish as above (St. Martin's) was formerly a gem in its way, being a small stone (Jersey conglomerate) structure of two parallel walls covered with capstones, with an oval peristalith surrounding it. Sad to relate, only two capstones were actually *in situ*, and the other stones scattered; still worse, however, these stones have been rearranged, and the remains cooked up to form a modern restoration of a prehistoric sepulchre. One of the present capstones (the fifth) is manifestly part of an upright which formed half of a partition, as exactly similar hand-worked stones are found forming partitions (to allow of entrance) in the covered *allées* of Brittany, and have been specially noticed by Mr. Lukis.

The cromlech of Mont Ubé, although devoid of its capstones, is still most instructive, being remarkable for the regularity of its form, which exhibits the original plan of the (Celtic ?) architects, perhaps more perfectly than any other cromlech in the Channel Islands. This cromlech is more fully imbedded in the soil than the denuded remains of the Pocquelaye and Le Couperon, which may tend to its ultimate preservation. It consists of a large western chamber elongated towards the orientated narrowed passage, and is divided into several chambers. Two of the upright stone pillars which separate the cists have been worked into somewhat obelisk-like forms, perhaps to adapt them for the reception of an imposed capstone. It is much to be regretted that several important stones have been removed from this cromlech.

The fourth cromlech in Jersey, only explored last year, appears to have the form of a covered avenue, but no large western chamber has yet been excavated. Several cinerary urns were discovered more or less perfect, besides a small stone amulet drilled with two holes, a few flint flakes, &c., with traces of charred ash and indications of osseous interments. This is the only case on record in the Channel Islands where no layer of limpet shells (although within a hundred yards of the sea) has been found. From this fact Mr. Lukis infers that the interments were not of the primary dolmen-builders. Some years before, some bronze celts were found in this

neighbourhood. The best Menhir in Jersey is a fine monolith called *Le Quesnel;* another, named *La Pierre Blanche,* is to be found not far from the Mont Ubé Cromlech. Under a flat Dolmen near Corbière Point, named *Table des Marthes,* some bronze weapons were found by M. Ahier many years since; but there is great doubt as to this stone being connected with the other megalithic monuments. Lines of Menhirs have been found in Greenland, where they appear to have been mainly erected to serve as landmarks during snowstorms, and some at least lead from the remains of huts to the nearest water. Capt. Parry notices, after remarking upon the remains of some stone-built Esquimaux huts, "We also passed a singular assemblage of flat stones set up edgeways, each about three yards apart, and extending at least five hundred yards down to a small lake situated in a grassy valley.*

The study of pre-historic archæology has now become a recognized scientific movement, but it may be remarked that, whilst the stone implements, ornaments, pottery, human and animal remains and interior "*finds*" generally have been assiduously collected in national and private museums, the cromlechs, sepulchres, and barrows containing these articles have not yet received their due amount of public attention. In all collections of pre-historic relics, which ought always to be *local* in order to be really instructive, there should be models (to scale) of the structures and localities in which the relics were found. No remains should be suffered to be taken away from the neighbourhood of the "*find;*" casts and facsimiles would answer the purpose in the national collections. The Rev. W. Lukis says "that the principal if not sole object of some investigators appears to be the possession of the articles which have been deposited with human remains. The object of the archæologist should not be the mere gratification of curiosity nor the accumulation of ancient works of art. A museum of antiquities is comparatively worthless if the history of the discovery of each particular specimen is not accurately known and recorded; these examinations should be made with the sole view of throwing light upon a dark period in the history of those who have previously occupied the soil."

This same gentleman has been so convinced of the necessity of examining and comparing the megalithic structures in Europe that he has spent four summers in Brittany, and (sometimes with the assistance of Sir H. Dryden) made accurate plans of the circles and avenues of Menhirs at Carnac, and throughout the Morbihan district. In his lectures on these structures Mr. Lukis draws attention to the fact that these lines or *Paralleliths* are universally orientated, and that they all terminate in circles at their western extremity; whilst the bulk and height of the Menhirs diminish

* Parry's 'Second Voyage,' p. 62.

gradually, and the widths of the avenues also diminish towards the east. He says, "There is a feature that is common both to groups of rows and to the sepulchres which may help to throw some light on the subject, *viz.* their orientation. By far the larger number of the sepulchral monuments, those I mean which are usually termed Dolmens, have their openings or entrances between the east and south points of the compass, *i. e.* nearly 90 per cent. are so turned, which it must be admitted cannot be an accidental circumstance. So too all the avenues are similarly orientated. If therefore the builders of the tombs had a religious reason for this arrangement, that same reason must have been dominant in the minds of the constructors of the avenues, and the inference is not without force that the same people erected both. There are *few* circles of stone *not* attached to avenues in the Morbihan."

It is in China, however, that chambered tumuli associated with megalithic avenues have attained, if not their hugest, their most elaborate development, in consequence of an ancient acquaintance with iron and steel tools. Thus we read that the great tomb (the "Ling" or resting-place of Yung-Lo, of the Ming dynasty), thirty miles from Pekin, consists of an enormous mound or earth barrow, covered with trees; its height is not mentioned, but is evidently considerable, from the fact that the circular wall which surrounds it is a mile in circumference. In the centre of this mound is a stone chamber containing the sarcophagus, in which is the corpse. This chamber or vault is approached by an arched tunnel, the entrance to which is bricked up. This entrance is approached by a paved causeway, passing through numerous arches, gateways, courts, and halls of sacrifice, and through a long avenue of colossal marble figures, sixteen pairs of wolves, kelins, lions, horses, camels, elephants, and twelve pairs of warriors, priests, and civil officers. Whether this avenue is orientated or not is not mentioned. An idea may be formed of the size of these marble figures from the following:—"During the building of the late Emperor Heen-fung's tomb a road 100 miles long was made from the quarries at Fang-shan to the Tung-ling, and a block of marble 15 feet long, 12 feet high and 12 feet broad, weighing 60 tons, was seen by several of us then resident at Pekin being dragged along this road, on a strong truck or car drawn by 600 mules and horses." . . . . "This block was to be cut into the figure of an elephant, to be placed as one of the guardians of the tomb." *

In order more fully to appreciate these pre-historic catacombs, and to comprehend the modes of their construction and the usages connected with them, we must follow Sir John Lubbock's example in comparing them with somewhat similar remains in use by modern savages; and we take this occasion to bring forward as

* W. Lockhart, 'Proc. R. G. S.,' 1866.

suggestive and parallel examples the methods of sepulture as practised up to this day by the tribe of Hovas, the inhabitants of the mountainous plateaux in the interior of Madagascar. The Hovas begin to erect their tombs in early life, and make their completion through a series of years one of the most important objects of their existence, as an effectual means of being held in honourable remembrance by posterity. These tombs are family vaults or catacombs, and in their construction an immensity of money, time, and labour is expended, limited solely by the wealth of the builder. In erecting a tomb the first consideration is the selection of an eligible site, publicity and elevation being the two principal requisites. Sometimes a tomb is placed immediately in front of the house of the person by whom it is built, so the tombs of the kings are within the precincts of the palace at Anantananarivo, the tomb of the first Radama being a conspicuous object in the palace yard. The site having been chosen, an excavation is made in the earth, and a stone vault made, the sides and roof of which are made of *immense slabs of stone, unhewn granite, flat at least on the inner side. Each side of this kist, sometimes seven feet high and twelve feet in length, is often formed of a single stone.* A sort of subterranean grotto is thus made, the entrance to which, always to the north or east, is closed by a large upright block of stone,* which is removed when a corpse is taken in, and fixed again at the termination of the funeral. In reading this, does it not remind one of our European kistvaens and cromlechs of the Stone age? This stone sepulchre is covered over with earth, and by means of stone copings gradually diminishing, presents from the exterior a pyramidal form. These structures, which we may call pyramidal tumuli, containing stone chambers, bear at all events a certain analogy to the chambered tumuli of western and northern Europe. Some of these structures measure 50 feet in length by 20 in breadth.

The large slabs used in forming these megalithic structures are usually of granite and syenite. The Hovas mark out the required dimensions of the slab by *odies* or charms (the idol-keepers being well acquainted with the cleavage of the rock, and taking advantage of this circumstance); large fires of cow-dung are made along the line thus indicated, and when the rock has become heated, water is dashed upon it, by which means, and with the help of long levers, large masses are detached from the mountain side. When the slab is to be removed, ropes of native hemp (rofia fibre, or the bark of the hibiscus, and a long tough grass are all used in the manufacture

* Compare Nilsson, 'The Sunny Side,' p. 127; also Ellis relates that one of the Hovas requested his sons, shortly before his death, that after his interment they would occasionally remove the large stone slab that would form the door of his sepulchre, and let the sun shine in upon him.

of cordage) are fastened around it, and amidst the vociferations of the slaves it is dragged away. In ascending a hill they place wooden rollers under the stone, and move them forward as it advances. Sometimes five or six hundred men are employed in dragging a single stone. A man usually stands on the stone acting as director. He holds a cloth in his hands, and waves it, with loud and incessant shouts, to animate those who are dragging the ponderous block. At his shout they pull in concert, and so far his shouting is of real service. Holy water is also sprinkled on the stone as a means of facilitating its progress, till at length, after immense shouting, sprinkling, and pulling, it reaches its destination. When the tomb is erected for a person deceased, but not buried, no noise is made in dragging the stones for its construction; profound silence is regarded as indicating respect. Sometimes a corpse is buried in a dwelling-house till the new tomb is finished, when it is removed to its final resting-place.

The dead body wrapped in a red *lamba* is placed on a bier, and a grave is dug for its reception within the vault, which is not paved: the corpse is placed in the grave without delay, and covered with earth, so that it is a grave within a stone tomb: a quantity of *fresh charcoal* is placed on the body to resist rapid decomposition: the wooden bier is left within the tomb by the side of the grave. It is customary at the interment of any man of note to deposit large quantities of property in the tomb with the corpse, especially of articles to which the deceased was known to be attached; thus, at the funeral of the first Radama, six of his favourite horses were killed and buried with him, a brass cannon was burst and, with a cask of wine, also buried with him, besides 10,309 silver dollars and upwards of 1000 articles of personal property, jewellery, &c.

The tombs are sometimes enclosed with stone walls, and within the enclosure are often two or three large upright stones.

The Hovas also erect stone pillars not dissimilar to our *Menhirs*, some of which are of a considerable size: they have no marks on them, and are called "*fahatsiarovana*," i. e. *causing to remember*. A name is also given them, derived from their position, "*mitsangambato*," *an elevated stone.*

Mr. Lukis, in examining some of the cromlechs and kists in the island of Herm, near Guernsey, suspects that some were merely ossuaries; that the bodies had been subjected to maceration elsewhere, and their bones deposited where found; so, also, Sven Nilsson* tells us that the Rev. M. Bruzelius found in the Asagrafven gallery-tomb in Scania, a vast quantity of human bones, from which he was of opinion that the flesh had been stripped off before being deposited in the vault, as he found in one place only the bones of the extremities and no vertebræ and in another a quantity

* P. 161.

of skulls. A similar conclusion was come to by Mr. Boye in examining a tomb at Hammer, in Zeeland. I find some almost similar instances among the Hovas of the present day, which may serve to throw some light on the subject. In Ankova the bodies of lepers are carefully bound up and rolled or thrown into a grave dug in any unenclosed space; here they are left interred beneath the soil for at least twelve months, after which they are dug up, the *bones cleaned* of all the flesh, wrapped in cloth, and deposited in the family vault. Again, the Hova warriors are always anxious that their remains should rest in the ancestral stone vault, and it is customary for comrades on a campaign to pledge one another that should one of them die, the survivor is to obtain and convey the bones of the deceased to his relations. In such a case every particle of flesh is stripped off the bones, which are brought with great trouble from the scene of action, however distant, and given to the nearest relatives, and buried with due ceremony. When the body cannot be found, after a battle for instance, it is usual to erect a cenotaph, which consists of an unfinished tomb, *i. e.* the three sides of unhewn stones, the fourth being left open for the disturbed ghost to enter and repose. Is it not possible that some of the apparently incomplete kists were erected with similar intentions?

The author noticed near Andevorante a tumulus on which were six upright conical stones about 6 feet high, which had been erected in memory of six Hova officers who died or were killed during Radama's campaign against the Betsimasarakas.

Before leaving the subject it may be as well to allude to the vestiges of the Vazimba, the supposed aborigines of Madagascar. These vestiges consist of small tumuli, or rather cairns, surmounted by an upright stone pillar, and are generally overgrown with thickets. These graves or altars are regarded with superstitious fear by the natives, both Hovas and other tribes: they occur in Ankova and in the western portions of Madagascar. These Vazimba are said to have been dwarfs, and are described by Rochon under the name of Kimos, and supply the same part in the Malagasy legends that the Lapps do as pigmies in the northern Sagas. There is little doubt that these Vazimba were the Hovas themselves, who, although not diminutive, are below the average stature, and who in colour, intelligence, activity, industry, courage, manufactures, and habitations, are exactly what Rochon describes the Kimos to have been. Like the Trolls and goblins of Scandinavia, the Vazimba have two characters; they are sometimes malicious and spiteful (*masiaka*), at other times benevolent and grateful (*masina*). It is curious that both in Europe and in Madagascar the pre-historic tumuli should be referred to these dwarfs and elves; thus in Sweden we have goblin caves and pigmy hillocks, and in the Channel Islands we have Pocquelaye, Creux des Fées, &c.

A few words about the stone-celt as associated with the presumed cromlech-builders of these islands may not be out of place here. These celts comprise all chipping or hewing stones, *Tilhugger steen*, which, according to their various modifications, may have been hatchets, axes, chisels, adzes, or wedges, and have been found generally throughout the islands in such numbers as serve to show how universally they were used as domestic implements in pre-historic times. They all belong to the Neolithic period of the Stone age; nor is it probable that any of the Palæolithic flints would be found on a granite island where little or no alluvial soil or drift gravel exists.

Mr. F. C. Lukis supplies me with the following list of celts, in his private collection, which he has obtained in the bailiwick of Guernsey (which includes Alderney, Sark, and Herm) alone, with the parishes in which they were found:—

Le Clos du Valle	33	Guernsey.	In round numbers 200. It must be remembered, however, that this list does not include *fragments* of celts, great numbers of which have been collected.
St. Sampson et l'Epine ..	46		
Ste. Marie du Castel	22		
St. Andrew's	21		
St. Pierre-Port	11		
St. Martin's	9		
St. Sauveur	6		
St. Peter-in-the-Wood ..	2		
Torteval	3		
Forest	2		
	155		
Herm	5		
Sark	25		
Alderney	12		
Total	197		

It will be seen from this list that the greatest number of these celts have been found in the parishes of St. Sampson and the Vale, that is, in the northern part of the island. Perhaps this may be accounted for by the circumstance that, prior to the year 1808, a large moiety of both these parishes was cut off from the main island at high water, and therefore less accessible; consequently even now there is more open common and waste ground, with less cultivation, than in the rest of the island. So also there are more cromlechs extant, and it is possible that their sites were chosen in this remote locality on account of its partial inaccessibility.

As to the celts, however, they are of all sorts and sizes, as observed above, and singularly enough the materials of which they are composed are not always native, as might be expected, but, on the contrary, are as often as not foreign, not only to these islands but to France and even to Europe occasionally, so that we are led to the conclusion that these instruments have been imported from great distances.

It is just possible that such implements may have accompanied immigrations of nomadic tribes (Indo-Scythians ?) from beyond the Caspian Sea, but at the same time they may have been exchanged or bartered, and thus have found their way so far west as Brittany. It appears evident that there was some commerce in such tools and weapons, which must have been highly prized, as many bear undoubted marks of having come from the same locality if not from the same *manufactory*. I use the word *manufactory* advisedly, for it is almost certain that at particular spots in Europe (where favourable geological formations gave ready access to valuable material, such as quartz, serpentine, porphyry, jasper, granite, greenstone (diorite aphanite), steatite, actinolite, flints, chert, agate, &c.), great numbers of celts were manufactured by the resident tribe, and exchanged with the neighbouring tribes for food, peltry, &c. Nilsson shows from glass heads being found among similar remains that the savage aborigines of Scandinavia had commercial intercourse with more civilized nations.

There is one peculiar celt made of a scarce mineral substance to which I must allude, as its presence in this part of the world seems unaccountable. It has never been particularly noticed, as far as I know, by any archæologist except Mr. Lukis, who long ago remarked upon it, and great interest must attach to it. I mean the celt made of *Fibrolite:* celts of this material have been found throughout France, the Channel Islands, and in England, and doubtless (although I have not seen any of the continental collections) throughout Europe; I am almost certain that there is one in Col. Lane Fox's collection from the River Irawaddy, and if so, that one came from much nearer its original home than those found here, for it is not known where any of this substance occurs in Europe; indeed, the nearest spot where it is attainable seems the *Carnatic.* If I am right in the above surmises it opens out a pregnant field for investigation. Similar observations apply with regard to the Jade* instruments, which are found in the Lake-villages of Switzerland. I may say that M. Schlagintweit relates the curious circumstance that Oriental jade-stone, when first taken from the quarries, is comparatively soft, not acquiring its extreme hardness until some time afterwards. The vulgar name for the celt among the peasantry of the Channel Islands is "*Coin de Foudre,*" as it is "*La Pierre de Tonnerre*" among the French countrymen, and the *Thunderbolt* of our English common-folk. The Swedes also, in common with the Irish, Scotch, and Welsh, have the same superstition as to their electrical origin. It has ever been a source of inquiry as to the spot where it (the celt) could be picked up after a thunderstorm; this idea has been confirmed in

* See Sir John Lubbock's 'Pre-historic Times,' p. 134, on the presence of nephrite in the Lake-dwellings.

Guernsey by numerous examples occurring, in which celts have been found immediately after thunderstorms, the fact being that it is only after thunderstorms that the people look for them. Some years ago the signal staff of the *Guet du Câtel* watch-house was shivered by lightning, and shortly afterwards a man in the same neighbourhood picked up close by a flint celt, measuring 6 inches in length. He was in the habit of chipping off little bits, and, applying the instrument to his nose, discovered the peculiar smell (well known when two pieces of flint are rubbed together), which he conceived, very wisely, proceeded from its mystical fire origin in the clouds. Among the common people the celt is supposed to have supernatural powers, and to have the virtue of preservation from injury.* It is often placed in the masonry of a house to preserve the same from lightning. Mr. Lukis is in possession of several, which have been obtained from old walls. They have been known to be kept on board of merchant ships, in the captain's cabin, for the same purpose. Mr. Rose tells us that the stone celts are highly valued in Denmark as charms, so that it is difficult to induce their possessors to sell them, as they were thought to bring good luck to the house. There is also an instance mentioned in which one of these ancient implements was found concealed under the floor of a cottage, near the door, having been placed there to keep out witches. In the Grecian Archipelago few cottages are without one of these stones, which is supposed to possess some sanitary virtue; the possessor breaks off a small portion of it when required, and either keeps it as a talisman against some particular malady, or dispenses it to his friends for the same purpose.

"One great source of danger to which this innocent implement is exposed is the fact of its being supposed to be thrown to the earth by fairies and hobgoblins. The old inhabitants of some of our islands, when they found one on their premises or fields, would immediately smash it to powder upon some stone. A Jersey gentleman has informed me that when he was a lad he had seen many treated in the same manner. Some years since I (Mr. Lukis) obtained a celt from a countryman of this island (Guernsey), and there arose a fearful storm of lightning and thunder in the night. On the following morning both husband and wife appeared at my house begging me to return the celt, as they had not slept a wink the night before.

"In Brittany the *Moen-sourous*, as the celt is called, is often thrown down into a well or spring as a purifier of the water. One well in the Morbihan is known to have had as many as five of those instruments thrown into it. In Switzerland the mountaineers are in the habit of wrapping one round the neck of the bell-wether,

* Compare Nilsson on 'The Stone Age,' chap. vi., pp. 199–202.

as a preservative against the foot-rot. We (Mr. Lukis and his sons) have obtained about a dozen from these shepherds."—Fred. C. Lukis.

Who or what this ancient people were who have left behind them their cromlechs and circles, Menhirs and tumuli, whether they are the same people who used these stone implements, yet remains undecided; but considering the remarkable results which have already been arrived at from archæological investigation, which, as far as the examination of pre-historic vestiges, dates only from the commencement of the present century, we may be sure that approximate, if not certain, conclusions will be arrived at sooner or later, especially when that important branch of ethnology, namely, craniology, shall have been fully developed by the successors of Retzius.

II. ON INSANITY.

By Dr. P. Martin Duncan, F.R.S., &c.

It is very remarkable how long a time it takes to disabuse public opinion of ideas which are founded upon the slightest evidence. The pertinacity with which such ideas are held generally originates in there being some palpable truth connected with them that hides some very unpalatable errors. Such a truth is all the more secretive when it refers to things which are to the credit of humanity, in contradistinction to those which mankind willingly forget as uncomfortable subjects. Thus there are some very general ideas current that the human race is advancing in mental power, that the diseases of the mind are not increasing, and that the Lunatic Asylum system is highly satisfactory on account of the cures perfected under it,—which have their origin in partial truths that have been carefully fostered, while the errors which make many inquirers demur have been shut up as social skeletons in the national closet.

The spread of literature and the increased facilities for national intercourse, the rarity of public exhibitions of the insane, and the acknowledged comforts and expensive surroundings of the unfortunates in asylums are patent truths which lead the superficial public to believe in the advance of education, the progress of that practical Christianity which is the test of civilization, and the surpassing excellence and usefulness of the lunatic asylum. The real truth sooner or later breaks upon men; and just as the present outcry for education is a proof of that want of it which has been protested against for years, so a murmur of discontent often heard of late is indicative of the commencement of the change in opinion, which must progress, about the origin of insanity, its relation to civilization, and the success of the present system of curation, which is fenced about by commissioners, the law, a staff of well-educated

medical superintendents, a few alienist physicians, and protected by the inertia of the English mind and by a good amount of the "rest and be thankful."

It is quite time to survey the curious opinions that have retarded the correct treatment of the insane, to notice what relation the increase of the disease bears to physical rather than to intellectual strain, and to show how unsatisfactory are the results of the great and expensive Asylum system in this country.

Probably there is no subject upon which non-professional people are more ignorant than that of mental alienation. There is nothing which speaks more loudly to their fears, and they consider insanity the direst calamity that can afflict humanity. It is usually looked upon as a mental death, as a condition which taints the family for generations, and which, if remedied for a time, is constantly on the point of recurrence. The curability of madness, and indeed its recognition as a disease within the ministry of man, are matters productive of much discussion amongst well-educated people, and there does not appear to have been much advance made by the public mind towards exact knowledge upon them.

There is nothing more evident than the thorough desire to do evil which is evinced by the majority of madmen, and the exceptions are so rare that they are popularly ascribed to the unusual amiability of the afflicted. Simple delirium which accompanies many ordinary complaints is constantly cited as a phenomenon which permits our evil nature to become manifest in spite of ourselves, and the indefinite nature of the current ideas upon the character of mental aberration influenced by these thoughts receives greater eccentricity when arguments are founded upon the ravings of the sufferers from delirium tremens. The horrible visions, the malicious mischief, the foul language, and the abject fear of the images floating before the eyes, so commonly illustrated by ordinarily quiet men under the influence of poisoning by stimulants, taken into consideration with the usual phenomena of insanity, present a series of dilemmas to those who will not hear of any intimate connection between the mind and the material body. Out of these difficulties there has ever been an easy path; but it is to be hoped that it will soon be closed by that Christianity which prefers to accept the conscientious labours of truth-loving men as its supports rather than incomprehensible dogmas. The bridges over the old road out of the dilemma were witchcraft, and the action of the moon and the devil. The first of these has broken down, and the influence of the idea of absolute possession by evil spirits has almost ceased, but not quite, to operate. Amongst the uneducated labourers of some of the eastern counties witchcraft is still an object of terror, and only a few years since, a crazy woman was considered "bewitched," and had to be protected from the violence of her fellow-villagers by the law.

Formerly all Europe considered the devil a better entity than the philosopher who insisted upon a connection between the physical condition of the brain and the immaterial mind. It appeared to be a solace and a comfort to have that evil presence at hand to demolish the pretensions of fellow-men; and as it has ever occupied a prominent position in the religion of the northern branch of the Aryan family, there was something almost sacred, with a tinge of goodness, in advocating its positive powers upon the minds of men, some of whom had led the purest and holiest of lives before their day of mental decadence. When priests went mad, it was hardly the thing to refer to the object of their constant antagonism. Profane men were known to jeer at the bell-ringing and holy-water splashing, and the general paraphernalia of exorcising, which were persisted in under the circumstances; but they were few in number, and public opinion, which would not admit any connection between the body and the mind, had no compunction about the spirituality of bronze, tallow, and water. Philosophers who desired to be orthodox shielded themselves under the influence of classical learning, which, being incomprehensible by the mass, was dearly loved by the few, and therefore universally reverenced. They quoted the myth which made Bacchus a mind-destroying god, and thus joined with the multitude in ascribing the seizure to some agency beyond the pale of materialism.

The occurrence of what has been called demoniacal possession being testified to in Holy Writ was never doubted, and the Scriptural proof of the Satanic origin of mania was strongly insisted upon by the clergy. Any attempt to deny this proposition was met with the usual charge of infidelity; and the suggestion that the possessed by devils were only so afflicted according to the prevailing method of scientific thought, and that it was a *façon de parler*, called up scornful accusations of atheism and freethinking. Priests and people stood up manfully for these Satanic rights, and it is really wonderful that the commissioners for the protection of the insane are not associated with some title which refers to the old popular idea of the origin of the affliction. They, however, bear witness to a popular belief which, after a sharp struggle, overthrew the diabolical theory to a great extent, for they are called "Lunacy" Commissioners.

Artemis had most varied relations with mankind. She was the assistant at his birth, she assuaged pain, blessed his industry, hunted him down when she was sporting, was insensible to the allurements of love; and the well-formed huntress and mistress of rivers liked to be propitiated from the time of Iphigenia with the blood of human sacrifices. She took to herself the attributes of Selene, and claimed the night-driven chariot. Medieval ignorance gave her moon, certainly a very material body, a very decided power over the demented. The full moon, so studied by witches,

was considered to be singularly pernicious to those whose minds were gone. So fast a hold did this opinion take, that, having a greater or less origin in an old myth, and belonging to the category of witchcraft and demoniac notions, it lasted, and has persisted, at least in name, until the present day. Moon-struck people are lunatics, and are under the care of Commissioners in Lunacy At present English science is committed officially to the belief in the lunar theory of insanity, just as it was formerly to the witchcraft and diabolical ideas. People still believe that the insane are worse at the full of the moon; and if the ideas of the multitude concerning the causes of madness are examined with a little critical care, it will be seen that they are founded upon the notions that bridged over the dilemma, and upon a curious opinion which brings the Great Ruler of all things, as the punisher, in immediate connection with the suffering mortal. The mind makes the man, and brings him in relation with his Creator. The perfect immateriality of the mind and its entire independence of the body being common beliefs, the particular influence of the Deity upon perversions of it is readily accepted as a necessary sequence.

Everyone must admit the overwhelming nature of the calamity of insanity, but modern science has proved that it ought to be as curable as other afflictions, or rather that a great proportion of the alienated ought to return to their former healthy condition of mind.

The influence of moral management and hygiene in increasing the number of recoveries in acute mania, and in shortening the duration of attacks, is perfectly evident, so that the ministry of man has much to do with restoring the alienated. There is no doubt that many become insane, and often incurably so, in consequence of long-continued moral and physical sins, and such cases come under the argument so ably elaborated by Bishop Butler. They prove that "there is a kind of moral government implied in God's natural government." Many suffer for the same natural sins, but not in the mind, and become hopelessly diseased in important organs. One class is as bad as the other, and yet in one series of cases the mind is affected, and in the other the mind is clear, the body being diseased. The immediate nature of the punishment can thus hardly be sustained, and we are forced to recognize its influence as operating secondarily and through certain definite physiological forces. These stand up like the tower of Siloam, and preach much the same sermon to the lookers-on. Were it not so, the ministry of man would be in direct opposition to the Creator's will, and the cures which follow the treatment of that insanity which has been produced by immorality and physical neglect, would be anomalies in the scheme of the government of the universe.

The Asiatics reverence insanity just as they do idiocy, and sufferers from it have been privileged since the days of David.

The demented and maniacal are not considered to be the victims of witchcraft, and to be persecuted by the Evil Spirit, nor are they supposed to be under the influence of the moon. The immediate influence of the Higher Power is invariably recognized, and no thought is given to anything like the production of insanity by physical disease, degeneracy of constitution, and hereditary taint.

The practical North Americans as a body—of course the highly educated are not included—either hold the indefinite opinions which characterize the thoughts of the corresponding public in England upon insanity, or would seem to believe, as English people did formerly, that the maniac is responsible for his violence and unreason, and that it does not much matter how he is treated, so that he is secluded. Even a curious kind of insanity is admitted to exist, which can be traced to have its diagnosis decided by offences against the former national proclivities. Thus an alienist physician living in the Southern States before the great war, described a species of insanity which affected the negroes. He compounded a name out of two Greek roots, which signified the bolting mania. The comforts and moralities of slavery were so well adapted for the African people, that the constant attempts at escape could only be looked upon as an evidence of insanity in the race which is so free ordinarily from psychological affections!

The treatment of some insane people in not very remote districts may suffice to prove that the Yankees have very materialistic notions about the disease, and that they do not hold the Asiatic opinions.

In 1868, Dr. Alexander Robertson visited the New York City Lunatic Asylum, and found that on the 31st December, 1867, of the 895 patients in the asylum, 304 slept on the floor, there being only 591 bedsteads in the wards. He writes:—"I was convinced that there is not sufficient room even for these (beds), as they are too near each other. Many of the bed-rooms are small and dark, having no windows, and are dependent for light and air on small openings into the corridors. In a large proportion two patients sleep together, and as the rooms only contain about 700 cubic feet, it is clear that the atmosphere must become very oppressive during the night, more especially in hot weather, such as at my visit, when the thermometer was standing at 100° Fahrenheit in the shade." There is about one homicide committed every year in these rooms. Strait-waistcoats, leather wristlets, and bed-straps to tie patients down in their beds, are part of the usual comforts of this disgraceful hole. Dr. Robertson sums up with—"Much disorder also prevailed in a number of the wards of this part of the establishment, many of the patients being stretched on the floor of the halls, some excited, others in a listless, moody, or apathetic state. Their position, however, seemed very much a matter of necessity, as there

was apparently not a seat for each, had they been all anxious to sit down at the same time. Both there and in the 'Separates' a large number were barefooted, and their clothing was untidy and ragged in the last degree. I noticed a man in one of the halls nearly in a state of nudity, his breast uncovered, his feet, legs, and fore-arms bare, and the clothing he had on hanging in tatters about his body, thighs, and upper arms. No remark was made about his condition, and it did not seem to attract attention as in any way extraordinary. As I have said, great excitement prevailed, more especially in the wards for the acute and violent cases. Never, in fact, have I visited any institution for the insane where the noise and confusion were so bewildering, nor where I experienced the same feeling of relief on leaving." The river runs by the asylum, and is supposed to check escapes, but suicides by drowning are "rather frequent." Four in six months was considered a favourable average!!! Scurvy frequently occurs amongst the patients, and four years since a large number died from typhus fever, and two years ago seventy died from cholera. The arrangement for religious exercises is most complete; three clergymen of various persuasions, and lay assistants being on the rota. The management of this outrage upon Christendom is by the Board of Commissioners of Public Charities and Correction, consisting of four members, who have been denounced by Dr. Beecher in his best strong language.

Dr. Willard published a report at the desire of Congress in 1865, and his opinion of the asylum was "that it was large and well conducted." . . . But, fortunately for his reputation, he had described others in the most straightforward manner, and, compared with them, the City Asylum was indeed superior. He notices that in Broome County Poorhouse "whipping is seldom resorted to" (for the insane). Columbia County Poorhouse: the great majority (all lunatics) are noted as filthy. Twelve sleep on straw, without bedsteads. The straw is changed once or twice a week. None had stockings during the winter. Portland County: the sexes are not kept entirely separated, and male attendants are employed to care for the female insane. Delaware County: the report, after describing the wretched cells, goes on to say,—"The sufferings of these unfortunates, from whom air and the light of heaven are shut out, would form (he might have written do form) a dark chapter of human misery, could it be written." Niagara County: "The whip is sometimes, though rarely, used to enforce discipline." St. Lawrence County: "Though no restraint(?) is used by handcuffs, whipping is resorted to, and the violent are put in cages to subdue them." Saratoga County: "Corporal punishment is administered to men, women, and children" (the latter remark apparently refers to sane paupers as well as lunatics). Tioga County: "They are seldom if ever visited by a

physician." Green County—"Six lunatics are confined in cells, five of them are in chains, including two women. Some are chained to the wall. They are in a wretched state, and none are cured or improved. In conclusion, the following quotation of Dr. Robertson from Dr. Willard's report may show the opinion of the Executive of the United States, that is to say if opinions infer conduct, upon the *status* of the insane:—"In some of these buildings the insane are kept in cages, in cells dark and prison-like, as if they were convicts instead of the life-weary, deprived of reason. They are in numerous instances left to sleep on straw like animals, without other bedding; and there are scores who endure the piercing cold and frost of winter without either shoes or stockings being provided for them. They are pauper lunatics, and shut out from the charity of the world, where they could at least beg shoes. Insane in a narrow cell, perhaps without clothing; sleeping on straw or in a bunk, receiving air, light, and warmth only through a diamond hole through a rough, prison-like door; bereft of sympathy and of social life, except it be with a fellow-lunatic; without a cheering influence or a bright hope of the future: can any picture be more dismal? and yet it is not overdrawn."

In Rome the picture may almost be drawn over again, and in fact wherever the influence of the intellectual classes is swamped by the masses or by an uneducated legislature. We, as a nation, have issued from this reproach hardly fifty years. It is still usual to connect lunacy with an indefinite something which implicates Providence and the dependence of the mind upon cerebral action, due reservation being made that there is nothing material between them. The present system of the treatment of the insane is founded upon these remarkably indefinite ideas, but it is a satisfaction to find that even the Commissioners in Lunacy, who originate with the Keeper of the Queen's conscience, have at last had the courage to associate mental perversion with physical decay. Let us notice how some old facts carry out their opinion.

It is excessively difficult to come to a satisfactory conclusion respecting the amount of insanity and its kind in uncivilized races, and also in those nations where civilization differs materially from our own. The most savage races do not come sufficiently in contact with accurate observers for a correct estimate of their freedom from mental disease to be formed, and the low type of their reasoning powers may oftentimes not render delusion and mild dementia prominent mental conditions. It is rare that any unusual strain is placed upon the minds of such savages; but when it occurs insanity appears not to be uncommon. Thus, some of Livingstone's faithful followers, who traversed the continent of Africa from west to east with him, were evidently rendered insane and suicidally so by the excitement consequent upon visiting residences of Europeans and

shipping. The occurrence of insanity in any of the African races is said to be very rare; but there is plenty of evidence that the negro slaves suffered considerably from several kinds of insanity, and their offspring also. This is also true for the slaves derived from other dark African races, who are not true negroes. Idiocy was frequent amongst the descendants of the imported negroes, and a low type of perfect intelligence, which was often perverted, was common, but was difficult of distinction on account of the mechanical and automatic action of the life of the slave. Drs. Bucknill and Tuke quote the testimony of Dr. Moreau in reference to insanity in Egypt. He found an asylum for the insane at Cairo,* but at Alexandria, where there was a population of from 80,000 to 90,000 inhabitants and many general hospitals, there was not even a ward assigned to the insane. He asserts that, on the authority of Dr. Gregson, surgeon-in-chief and resident in Egypt for nearly ten years, that insanity is very rare. The Doctor only saw one example of the disease in that period. Dr. Moreau says that as the civilization of Egypt is left behind and the Delta becomes more distant, lofty mountains and desert plains, tents and cattle, successively replace cultivated and fertile fields, habitations and bazaars. With the soil man becomes more degraded, his intellectual activity diminishes, and is at last reduced to a minimum, absorbed as he is in the necessary wants of physical life. Among this population the insane become fewer and fewer in number. I have not met with a single one, not even an idiot, writes Dr. Moreau, in all Nubia. Several of my friends, he continues, who have visited Sennaar, Cordofan, and Abyssinia, have found only here and there a few imbeciles. The same testimony has been adduced with respect to the Guinea Coast. Dr. Moreau suggests, however, that many of the Santons are really insane, and recent travellers in Eastern Africa might almost say as much for the brutal chiefs of some tribes. Nevertheless the rarity of insanity amongst the African populations appears to be established.

Dr. De Forest, of the Syrian Mission,† says "that it is impossible to obtain accurate statistics of the insane here; but I think the disease far less frequent than in our own land." There would appear to be more insanity amongst the Syrians than amongst the African races, the Syrians being a very mixed race. Insanity is said to be less frequent amongst the inhabitants of Bengal and less acute than amongst the civilized races of Europe; but its admitted increase is accounted for by the introduction of European vices. Polynesia appears to be comparatively free from insanity; and its natives, with those of the Australian and New Zealand islands, have received accessions of the disease simply

* Some years since the lunatics in this asylum were treated just like wild beasts.

† See Bucknill and Tuke, page 40.

through their contact with the worst parts of our civilization. The Chinese and the races associated under that name, and which constitute so large a proportion of the population of the world, are said to be remarkably free from mental diseases, if the prejudicial effects of opium be not considered. The majority of the cases of insanity observed by European physicians in China had their origin in opium smoking; and it is generally admitted, although the opportunities for a close examination of the question have been very slight, that mania and dementia are rare there. No country has passed through more exciting scenes during the last twenty years than China; and rebellion, wholesale massacres, wars with Europeans, and great social changes must have produced their exciting and depressing effects upon a race which is singularly domestic in its affections, much more industrious and saving, and more learned than any other of the Asiatics. The amount of insanity in this great empire can really not be estimated even approximately. In considering the question, some of the peculiarities of the race must be remembered. The ready disposition to commit suicide which is common to the races on the mainland and to those of the islands, including Japan, the sale by men of their own lives for comparatively trifling sums of money, and the suicidal despair which readily affects Chinamen under severe disappointments and hardships when working in distant countries, indicate that the insanity of the people may take on very different phenomena to those observed amongst European nations. The sudden outbursts of murdering passion observed in the Malay race may be taken as an evidence that the great peculiarity of insanity amongst its members is violence, and that ordinary monomania is hardly to be expected.

There is some amount of insanity amongst the rapidly decreasing New Zealanders; but here, again, the effects of European vices are evident. The history of the race is one continued warfare, and it may be conceded that in this instance, as in all others of the same kind, this constant pugnacity must hide a good deal of unreason. A chief whose insanity assumed the ordinary type observed amongst warlike savages, and was persevering in his enmity, cautious before the fight, and furious during and immediately after bloodshed, would not be deemed a madman. Doubtless there have been many such heroes in the world's history. These remarks will apply to the native tribes of the American continent and to the comparatively unknown races of Central and Western Asia; but it should be remembered that amongst the more nomadic nations the constant migrations and the frequent absence of a settled home must give any of the mentally afflicted a poor chance of keeping up with their fellows in the struggle for existence. The amount of insanity amongst the Mahommedan nations is probably much greater than is ordinarily believed, and there is no doubt that those religion-

ists who manifest their sanctity by extraordinary physical exertions and tortures contain a large percentage of men who are not much more mad than the founder of the Faithful was.

It is impossible to admit that many of the great conquerors who were the curse of the world were sane. Cambyses, Alexander, and Attila were subject to attacks of homicidal mania, which were only salient points in a long period of unreason qualified by the prevailing warlike spirit. Their insanity took on the type which reflected the ordinary disposition of the age. So did that of Saul and Ajax. It is hard to believe in the sanity of Domitian and Nero, or of many of the emperors whose bloodthirstiness was appalling, and whose cruelties were atrociously wanton, and especially as madness was so common in the best days of Rome that its symptoms have been admirably rendered by the physicians of the period. Violence, homicide, and suicide, although the most marked of the symptoms of the earlier civilizations, were not unaccompanied by the melancholy madness so common at the present time. Hippocrates notices a case of melancholia in a woman of his day, "from an accidental cause of sorrow." She lost her power of sleep, and had aversion to food, and suffered from thirst and nausea, being of a melancholic turn of mind. Her cure by nature is recorded also. The method of madness simulated by David bears witness to the acquaintance of the Philistines of Gath with the complaint, otherwise the stratagem would not have had the desired result. Thus early in the history of the world the sanctity of the insane was clearly acknowledged. The unsatisfactory notices of uncivilized and ancient madness appear to indicate the prevalence of violent maniacal and homicidal attacks, and the opposite condition of imbecility. There is every reason to believe that the affliction does not increase amongst savage nations, and that it never attained a very great importance in classical times. Probably the mass of the demented of Europe was not represented by a corresponding type of disease in the olden time. The truth is melancholy enough now.

The increase of the population of England and Wales and Scotland year by year is beyond doubt; and unfortunately, so far as England is concerned, there is no doubt about the yearly increase of pauperism. Emigration has been compensated for by the annual excess of births over deaths, and it is certain that the exodus has not taken away a great proportion of the best of the peasantry, as it has in the case of Ireland. The condition of the agricultural labourers and miners has slightly improved; but that of the population of the worst parts of our great cities has retrograded.* On the other hand, commercial enterprise and great engineering opera-

* At a recent meeting of the Liverpool Select Vestry, a brewer (*sic !*) attributed the fulness of the lunatic asylums which he had visited to indulgence in poisoned beer.

tions have raised a vast number into the lower middle class, and have excited increased mental activity and its corresponding anxieties. The mercantile world has passed through great ordeals, and wealth has been unusually uncertain during the last few years. There is hardly a small circle of acquaintance that cannot tell of some ruin amongst people who have been prosperous; and the details of the results of the immoral conduct of "financiers" abound with lists of the well-educated who have to put up with the greatest privations, and whose mental sufferings can better be imagined than expressed. According to the popular idea the increase of insanity should have been found amongst the middle and upper classes, and the private asylums should have received an unusual number of patients of late.

The following Table, taken from the last Report of the Commissioners in Lunacy, is singularly corrective of the popular idea, and confirmative of those opinions which connect insanity rather with defective constitutional vigour and a low state of the nutritive functions than with increased mental strain and anxiety.

INCREASE OF PRIVATE AND PAUPER PATIENTS IN THE ASYLUMS OF ENGLAND FROM 1863–67.

Year.	Total Number of Pauper Patients on 1st January.	Increase during the Year.	Total Number of Private Patients on 1st January.	Increase during the Year.
1862	20,949	..	5250	
1863	21,998	1049	5340	90
1864	22,958	960	5327	− 13
1865	23,763	805	5177	−150
1866	24,995	1232	5277	100
1867	25,998	1003	5286	9
Increase in 5 years		5049	..	36

It will be seen that there is a steady increase of our pauper lunatics, at the rate of about 1000 a year, whilst there are only thirty-six more private patients in asylums than five years ago. The increase of the general population has been great, yet the small number of 36 when placed *en rapport* with its numbers amounts to nothing as regards increase, and infers a decided decrease.

The Table is carried on in the Report up to 1868 and 1869, and the number of pauper lunatics admitted into asylums in those years was 27,363 and 28,728 respectively. But this return does not refer to all the pauper lunatics; for the workhouses contained 7963 lunatics in 1859 and 11,181 in 1869; and there were 5798 insane paupers in 1859 living with their relatives, and 6987 in 1869. Thus the whole pauper lunacy of England and Wales amounted to 31,782 cases in 1859, and to 46,896 in 1869. The population in 1859 amounted to 19,686,701, and in 1869 to

21,869,607. That is to say, with an increase of population of 2,182,906, there were no less than 15,114 pauper lunatics. In the corresponding time, and with the same increase of the general population, there was a gross increase of 840 cases amongst those who came under the notice of the Commissioners as private patients in asylums and at home with their friends and committees.

Doubtless many a lunatic whose friends are above the pauper class is kept at home and escapes the notice of the Commissioners, but any increase in the numbers of the "private" class which might accrue in this manner is compensated for, when the relative numbers of the insane are considered, by the number of pauper lunatics who are aged and simply demented, and who are not under supervision. There appears to be a reasonable foundation, then, that there is a decided increase in the lunacy of the pauper class, and that it is slight among the non-pauper class.

This assertion has been most ably and temperately contradicted by one of the late presidents of the Medico-Psychological Association, and in 1861 by the Commissioners in Lunacy. They then wrote the following sentence, which very properly heads Dr. C. Lochart Robertson's essay on the subject:—"We have not found any reasons supporting the opinion generally entertained that the community are more subject than formerly to attacks of insanity."* In 1869, Dr. L. Robertson wrote, "that the alleged increase of lunacy is a popular fallacy, unsupported by recent statistics." He quotes the words of the President's address, read July 31, 1867:—"During this period (1847–1867) the total number of pauper lunatics and idiots has increased from 17,952 to 42,943. While in 1847 one in every 880 of the whole population was a pauper lunatic, this proportion is now, in 1867, one in 494. I do not attribute these numbers to any actual increase in insanity, but rather to the fact of the more accurate returns which are now made of the pauper lunacy of the country, and also in some degree to a number of persons in the lower middle class successfully contriving to evade the restrictions of the poor law, in order to procure for their insane relatives treatment in the county lunatic asylums. This opinion of the absence of any positive increase in the lunacy of the country is further supported by the relative proportion of private patients to the population in the same period."

Popular fallacies and general impressions are very obnoxious to the dogmatic under any circumstances, and they become exasperating when they receive support from the most recent and official statistics. The following Table from the Commissioners' Report for 1868, published July, 1869, gives support to the "popular fallacy," if figures are of the least value, and unless the Commissioners wish to throw dust in our eyes.

* Report, 1861.

Year.	Population.	Total Number of Lunatics, January 1.	Proportion to Population.
1859	19,686,701	36,762	1 to 536
1860	19,902,713	38,058	1 " 523
1861	20,119,314	39,647	1 " 507
1862	20,336,467	41,129	1 " 494
1863	20,554,137	43,118	1 " 477
1864	20,772,308	44,795	1 " 464
1865	20,990,946	45,950	1 " 457
1866	21,210,020	47,648	1 " 445
1867	21,429,508	49,086	1 " 437
1868	21,049,377	51,000	1 " 424
1869	21,869,607	53,177	1 " 411

The gradual and progressive increase is, according to this Table, most evident; and if the Table of the increase of private and pauper patients in asylums already noticed is examined, the same remarkable support to "popular fallacy" is given. The increase of the number of admissions is evident. Unless there is an increase in the lunacy of the general population, and especially in the pauper class, these statistics must be misguiding and erroneous. It may be asked when did the inaccuracy of the returns culminate, and when did the operations of certain Acts of Parliament particularly influence the singularly and equably progressive percentage noticed above. The operations of the Act of 1843 may have suddenly swollen the returns up to 1859, but it certainly did not do so afterwards. The Act of 1861, writes Dr. L. Robertson, "rendering pauper lunatics chargeable upon the common fund of the Union, instead of on their parish, led to a further increase in the number of lunatics and idiots sent to the county asylums." But, on comparing the proportion of the lunatics to the general population in the years 1862, 1863, and 1864, when this increase of admissions to asylums would have taken place, there is no proof of any great access to the number of known lunatics, and simply because they were all allowed for in the returns of the Commissioners before the passing of the Act.

Since 1862, the statistics of the insane published by the Commissioners have not been subject to any disturbing causes; they are not calculated to mislead in the manner suggested, and we are bound to accept the fact that there is a steady increase in the lunacy of the population of England, Wales, and Ireland, especially amongst the pauper class, and to admit that for once popular fallacy is supported by recent statistics.

The bearing of statistics upon the ultimate causes of insanity is evident. It warrants the plain statement of Dr. Richardson,—"Our uneducated cloddish populations are, in short, as I venture to assume, the breeders of our abstract insanity; while our educated,

ambitious, over-straining, untiring mental workers are the breeders and intensifiers of some of the worst forms of physical malady;"* and it is very ably considered by the Commissioners,† who write as follows:—"The population of England may be estimated in round numbers of 20,000,000, of which 1,000,000 are paupers; and we have thus the remarkable fact of an increase in asylum patients in five years of 5049 from the million of paupers, and of only 36 from the 19,000,000 of non-paupers. Making very liberal allowance for the pauperizing effects of lunacy, and the consequent removal of a considerable number of patients from the independent to the pauper class, we are thus forced to the conclusion that insanity *is essentially a disease not of the overstrained intellectual or emotional faculties, but of the depraved bodily condition which for the most part is dependent on insufficient or inappropriate food, irregular living, overcrowded dwellings, long-continued nursing, overwork, fever, or any similar cause of bodily debility.*" They might have added the influence of want of mental exertion, and of hebetude produced by the sameness of the mental surroundings; for a large section of the human race dies more or less insane from prolonged stupidity.

The number of the insane in Ireland should afford a very satisfactory proof that the affliction accompanies, and is more or less produced by causes which relate to the general nutrition and vital force, instead of those which have to do with exaggerated emotions, intense mental work, and hard labour.

The population of Ireland is steadily decreasing, and the agricultural wealth has been on the whole increasing for the last ten years; but the condition of the agricultural class is very much the same as it was fifty years since. The constabulary obtain very exact returns of the numbers of the insane who do, and who do not receive parochial relief; and thus the whole amount of mental alienation may be determined very correctly. The returns made by the asylums, workhouses, and gaols, taken with those of the constabulary, and compared with the decreasing population, show a decided increase in the numbers of the insane from 1851 to 1861, and that although there has been a decrease in the population since 1861, there had not been a corresponding decrease in the numbers of the alienates.

Dr. MacCabe has given some very interesting statistics concerning the county and city of Waterford, which maintain a considerable agricultural and a small urban population. He considers the district to present a fair picture of an average Irish agricultural district, the population of the city of Waterford qualifying a character that might otherwise be described as exclusively agricultural. In 1851 the lunatics of all classes in Ireland numbered 15,098, being in the proportion of 1 in 433 of the popu-

* 'Journal of Mental Science,' October, 1869. † Report, 1869.

lation, which was 6,552,385. Ten years later, in 1861, the population numbered 5,764,543; a decrease of 12·20 per cent. The number of the insane thus amounted to 15,947, or 1 in 361 of the population.

Dr. MacCabe gives the following statistics of Waterford:—The county and city comprise an area of 721 square miles, or 461,553 acres, of which in round numbers 325,000 are arable, 105,000 uncultivated, 23,000 in plantations, 1500 in towns, and nearly 6000 under water. In 1851, four years after the famine, the population of the district amounted to 164,051. The numbers of the insane were:—In the asylum, 121; in workhouses and gaols, &c., 61; at large, 56: total, 238. Ratio to the population, 1 in 689.

In 1861 the population of the district amounted to 134,336, a decrease in ten years of 29,715. The numbers of the insane in the district were:—In the asylum, 135; in workhouses and gaols, 69; at large, but returned by the constabulary, 182: total insane of the district, 386. Ratio to the population of 1 in 348.

In 1868 the population had evidently declined from the figures given in the census of 1861. The numbers of the insane were:—In the asylums, 167; in workhouses and gaols, 90; at large, 120: total insane of the district, 377. Ratio to the population, 1 in 358. The increase in the numbers admitted into the asylums and workhouses depended upon the operation of Acts of Parliament, but the significance of the sum total is not to be mistaken. There was an evident increase in the numbers of the insane for ten years, and no decrease of any amount since 1861, so far as Waterford was concerned.

The last returns of the insane population of Ireland for 1867 and 1868, December 31st, in both years are, for the first year, 15,650; and for the last, 16,018. In 1861, it has been already mentioned, the insane numbered 15,947. Of course a correct estimate of the relative numbers of the insane and sane cannot be obtained until the census which is about to take place is completed. But, as a matter of fact, it is known that the general population did decrease from 1851 to 1861, and there is a strong presumption from the emigration returns that a steady exodus makes a sad inroad into the ranks of the peasantry year by year. No one credits that there is any increase of the population, and therefore the numbers of the insane must be believed to be on the increase, and to have increased year by year in Ireland in relation to the population.

Esquirol's remark that insanity belongs almost exclusively to civilized races of man, and that it scarcely exists among savages, being very rare in barbarous countries, holds good; and the experience of the last twenty years proves that he might have said with great truth that in the most civilized countries where there is the

greatest wealth, industry, and learning, there there is the greatest poverty and misery and the largest amount of insanity.

The success of the treatment of the insane, so pleasurably commented upon by our legislators and by magistrates in sessions, can be estimated by statistics, and the result of a fair inquiry is remarkably unsatisfactory.

Thirty-five years have elapsed since Prichard's celebrated treatise on insanity appeared, and during that time the asylum system and the "moral management" treatment have gradually attained a great development; that is to say, the old miseries of the insane have to a great degree been replaced by conditions which at least are very satisfactory to the public. If insanity were not a curable disease, if it were perfectly beyond the action of remedies, and if it were a special affliction far beyond the influence of material entities, civilization might be congratulated upon having influenced the minds of men in the direction pointed out by the philosophy of Christianity. Fine buildings, many of them admirably adapted for their object; delightful grounds; elegant corridors, hung with pictures and ornamented with flowers, and decorated with taste; a large staff of nurses and attendants; well-educated and benevolent medical men; a perfect system of hygiene, diet, and supervision, and sedulous commissioners and visitors. These are the most prominent accessories of the modern system, and they are most creditable to humanity. But when Hodge's wife leaves him in a snug ward, whose surroundings are quite palatial to her wondering senses, and returns to her dirty hole of a cottage, to satisfy the hunger of half-a-dozen young children upon bread, dripping, and tea, she wants to know whether all this splendour will cure her John safely, quickly, and pleasantly, and what he will think of home when he comes out. The people who sent her John to the asylum know that he will not be cured cheaply, and some have the curious taste to say that if it were not for those confounded lunatics many healthy-minded individuals might have a holiday now and then. As it is, the rates are the devourers of such luxuries. Some restless inquirers have not yet been sufficiently educated up to the proper appreciation of the grandeur of the modern system, of its psychological literature, and of its staff of officials and commissioners. Such Bohemians will ask questions which are considered proofs of gross ignorance by the profession: and some have the assurance to assert that the magnificent accessories of the treatment of insanity have not been of great assistance to humanity. They urge that lunatics are not more frequently cured than they used to be; that the number of recoveries from insanity has not been increased; that the holding down of violent patients and the fracturing of their ribs by keepers is not a bit better or more Christian treatment than placing them in strait-waistcoats and fastening them down

with straps; and that the whole asylum system is uselessly expensive and detrimental to the majority of the insane and unphilosophical, especially as no means have been adopted by the State to prevent the occurrence of that misery and pauperdom which develops lunacy.

Many independent thinkers, whilst they admit the sedulous care that is taken of the insane in asylums, and believe that cruel treatment is very exceptional, are by no means satisfied that much progress has been made by medical science in the cure of the alienated. The inmates of asylums are well taken care of, and they are as comfortable as they can be; but with all this there is a doubt whether the cures increase year by year with the experience of the psychological gentlemen. There is even a doubt expressed about the applicability of the asylum system to many cases of chronic insanity, and the Commissioners hint at a want of individual attention to demented patients. Certainly the Commissioners have forced the present system of shutting up all lunatics upon the nation, and have necessitated an enormous expenditure; but it becomes a serious question whether the whole of the insane who are not affected with the disease in its acute form, and who are not dangerous to themselves and others, would not be better off under very different circumstances than those of the model asylums. The heavy expense of the present system is admitted, and the anxiety of the physicians to do their best also. Now let us consider some results.

Prichard, writing thirty-five years since, notices the remarkable results of Dr. Burrows' treatment. He writes:—"Dr. Burrows has reported from his own experience 240 cures in an aggregate of 296 cases of various descriptions; 221 cures from recent cases; 19 cases from 64 old cases; affording a proportion of 81 in 100 of all cases." He acknowledges the general surprise that this high percentage of recoveries has excited, but notices that it coincides nearly with the statements of Dr. Willis. Dr. Jacobi, of Siegburg, in Westphalia (1830), cured 40 in 100 cases, and kept his patients sufficiently long under his eye to render any doubt about their perfect cure impossible. Esquirol collected the results of 5360 cases, and found 2691 recoveries, and this was between A.D. 1798 and 1813. This is at the rate of nearly 50 per cent. In a report made officially in Paris in 1825 of the state of the hospitals for lunatics during the three preceding years, and which was considered by Dr. Burrows, the recoveries were proved to be 34 in 100. Esquirol tabulated the returns from English lunatic hospitals from 1748 to 1814, and found that the percentage of cases was about 33 against the 50 per cent. in France. The cures at Bethlehem Hospital from 1819 to 1833 amounted to rather more than 50 per cent. In the Stafford Asylum, from 1818 to 1828,

the cures were about 43 in 100 admissions. In Wakefield County Asylum from 1819 to 1826 the cures were 42 in 100. In Lancaster County Asylum from 1817 to 1832 the cures were about 40 per cent.

The Gloucester Asylum from 1823 to 1832 dismissed nearly 50 per cent. of its inmates cured. The same average result was obtained in the Retreat, near York, from 1812 to 1833.

Now it must be admitted that the treatment of the insane was, so far as comfort and science were concerned, at a very low ebb during the early twenty-five years of this century. The "magnificent period" has lasted from 1835 to the present day. What do the statistics of recoveries (which relate to the past thirty years) prove in comparison with those just mentioned, and which belong to the past? In the Somerset County Asylum 3284 patients were admitted from 1848 to 1868, and the recoveries were 42 per cent. The average number of the cures of the Scottish Asylums amounts to about from 37 to 40 per cent. The average percentage of recoveries to admissions into English asylums during the past ten years has been, for the county and borough asylums, 33·93; and for the private licensed asylums of the metropolis, 27·60. It follows that the cures of the insane in our fine asylums are not more numerous than they were from 1748 to 1814, when the treatment of the insane was a disgrace to humanity. If anything is to be made out of the statistics, the percentage of cures has rather fallen off. Whilst every other disease has been less persistent and has been more curable, insanity remains as a dead-weight on the statistics of our social miseries. To refer this unsatisfactory state of things to the comforts of asylums, or to the system of treatment adopted by the able men who labour in this thankless part of the medical profession, is simply absurd.

The cause of the mass of incurability is tolerably evident, and the defects of the system which prevent a cure are so also.

It is admitted that the majority of the insane are more curable during the first year of the attack than subsequently, and that mania is, as a rule, followed by recovery in from 90 to 95 per cent. of cases. But every month that elapses without amendment in the mental condition complicates the affliction and diminishes the chance of recovery. Every relapse acts in the same manner. The quiet and chronic cases are of course those whose persistence in the same state renders the percentage of causes so unsatisfactory. Not only is the malady produced in them, either by hereditary predisposition, by a long perversion of the nutrition of the brain by reason of mental and moral abuse, or by organic disease, but it is perpetuated by the rest-and-be-thankful treatment which sooner or later must be adopted under the present system. The routine of an asylum and its moral and physical atmosphere act after a while per-

niciously. The want of definite work, of exercise which interests, of relief from miserable sights, and of those happinesses of home which cannot be replaced by any luxurious comforts, together with the effects of the dismal companionship of fellow-sufferers, during the periods of temporary sanity, are constantly producing depressing results. Dr. Boyd, writing in 1869, states that in his experience the tubercular class of diseases produces very fatal results in the chronically insane. He remarks, that "However we regard the fact, whether from the numbers collected, or from insanity being more prevalent amongst phthisical (consumptive) patients than others, or from both causes, the mortality from tubercular disease was about double amongst chronic cases of insanity in both sexes to that of the adult male and female population of England in 1866." The longer the duration of the residence in the asylum, the greater was the mortality from consumption.*

In ordinary medical practice the consumptive are not more frequently transferred to the alienist physician on account of mental derangement, than those suffering from other diseases, and of course less frequently than those with disease of the nervous system. It is the depressing effect of association and of the want of physical labour that adds to the list of the consumptive in our great asylums.

Here, then, is one of the most prominent causes of the incurability of the insane brought into definite relation with the asylum system. Even if it were admitted, which it cannot be, that the majority of the insane are afflicted with tubercular diseases before they enter asylums, the peculiar arrangements of the establishments are not those which would benefit the constitution or retard the issue.

Consider another point. The miseries and the excitements of one age were pretty well equalled in all others; but it is by no means clear that education, however trivial, does not add to the wretchedness of the pauperized, and of those who, whilst they witness the splendid luxury and waste of their fellow-men, are dragged down by circumstances into a hopeless condition of semi-starvation and drudgery whose only termination is in a long vista of want, with the poorhouse and grave in the distance. The want of mental and physical resiliency amongst the poorest of our urban and agricultural populations is evident to those who care to mix with them. The well-disposed and honest are in constant fear about the sustentation of their families, and the careless are, as a rule, steady drinkers and unsteady workers. The wants of the primitive condition of mankind are superadded to the miseries of our social state; and the poverty, which is hardly ever to be cast off, prevents that healthy direction of the mind and senses which the early hunters enjoyed, but which appears to be incompatible with the present state of things. There is nothing wonderful, then, in the state-

* 'Journal of Mental Science,' 1869, pp. 200–2.

ment that the present condition of the pauperized, and of those who must become paupers in the ordinary course of events, is favourable to hebetude and to mental decadence, as well as to physical degeneration. It is clear that the majority of the pauper insane enter asylums with the malady in their very bones, and year after year hereditary predisposition adds to its intractable nature. Our social state is producing year after year an increasing amount of insanity more than ever difficult of cure.

It is evident to those who can consider the question dispassionately that the method of treatment of the majority of the chronic cases forming the bulk of the inmates of asylums is inordinately expensive, unsatisfactory as regards its results, and not right in principle. It is a failure. There is no doubt about the efficiency of the treatment adopted in asylums in cases of mania and in those where suicide is feared; moreover, there is a social necessity for separating those thus afflicted from their fellow-men. The total alteration of scene and diet, the moral influence of strange faces, and of the clock-like regularity of the establishment, constitute, however, with that valuable medicine, time, the principal curative agents. Medicine, so far as drugs are concerned, has advanced very slightly since the time of the Greeks in the treatment of insanity, and no important addition to our knowledge concerning the relation of drugs to insanity has emanated from the alienist physicians of the past twenty years. Every severe disease has attracted the urgent attention of the medical protession, and those which were formerly very fatal are now so managed that a cure is by no means rare, and, moreover, it bears a definite relation to the administration of drugs. But the medical treatment of the insane is in the hands of a few, and the alienists constitute a very close borough: so of course no progress commensurate with the spirit of the age is made. Kind Nature cures the majority of the lunatics who recover, but she certainly does not get the credit. She is opposed by the asylum system in the cure of the chronic cases, and therefore they remain much the same as fifty years since.

Our social errors produce such types of madness that even the Commissioners are downhearted, and begin to be philosophical. They write, despairingly, as follows:—

"Hitherto our efforts have been mainly directed to the provision of asylums for the cure and care of the insane; but these efforts, however beneficial they may be in many respects, have, as we have seen, totally failed to meet the increase of lunacy. That more successful results would be obtained from the rational education of the people, and from the introduction of physiological instruction into schools, may very reasonably be expected. The prevention of insanity is not only a far nobler aim than the provision of accommodation after the mischief has been done, but it is one which

there is reason to hope would greatly contribute to sap the sources of pauperism."*

The rational-education cry is all very well, but, for reasons already given, there may be much doubt whether it will be the panacea for lunatic pauperism. Our difficulty is not, however, at present how to prevent insanity, but how to treat the apparently incurable—those who do not receive benefit from the present asylum system—properly and successfully, and without extravagant outlay. When a system is fully developed, any proposition which interferes with it is of course ridiculed. Just as the asylum system was a matter of slow growth, and one full of trouble and mistakes, so all others, more or less antagonistic to it, must commend themselves to us, whilst they pass through stages of incompleteness, misdirection, and error. If the insane colony of Gheel is mentioned as a reasonable institution, its shortcomings are of course placed prominently before us, but really they are equalled in many English asylums, and its statistics prove that the unfortunate patients afflicted with chronic insanity are cured in about the same ratio. They have more liberty, and it is possible for them to wear out their irritability by continuous labour. Certainly they do not cost so much for maintenance as the English demented, who crawl about the yards and grounds of the asylum like flies out of season. But a system of treatment of the chronic insane on the Gheel plan, and without its evident errors, would give the afflicted a better chance than they now have. There are many large asylums with plenty of land around them, and some of the insane work on the land; but this labour is not universal, and its mercantile value is always considered. If a superintendent turned the whole of his chronic cases out into the fields day after day, and managed to direct the attention of each one to work which was possible, it would not be a more troublesome proceeding than teaching a class of idiots (and this is well done, after a while, with perseverance), and the benefit must be great. If a great village, with proper cottages, was founded in each county on land which could be cultivated without any great loss by skilled labour and by the chronic insane, the success would not be less, so far as curation is concerned, than it now is, and it might be greater. The comforts of the patients would be the same, and the same staff of officials would be necessary. The dreary walls, the awful sameness of surroundings, the close company of fellow-lunatics sadly differing in mental peculiarities, would be got rid of, and the restraint would be reduced to its minimum. Doubtless there would be occasional scenes of trouble, excitement, and violence; but are there not such within the walls of the best-regulated asylums? Perhaps they might be less frequent under the open canopy of heaven. As a matter of expense,

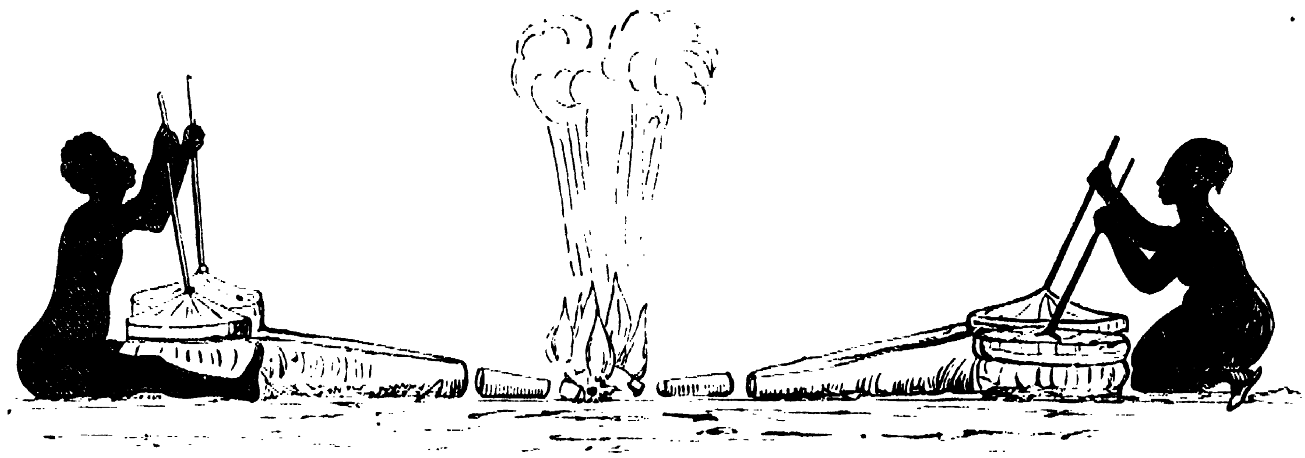
* Report, 1869.

there can be no doubt that the village system would be very economical, in fact just as reasonably so as the present asylums are scandalously expensive when their expenditure is contrasted with their results.

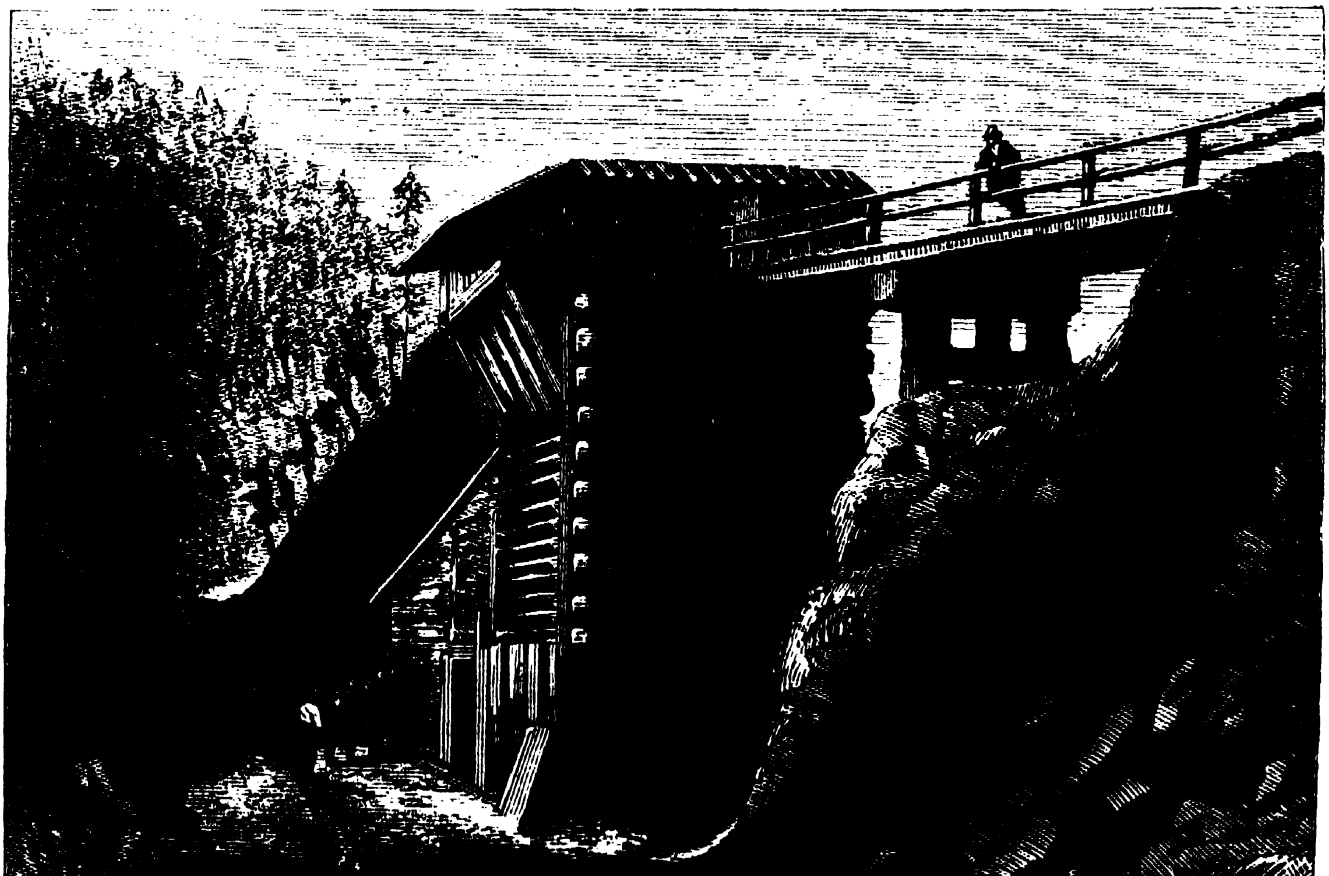
The old notions concerning the origin and nature of insanity are rapidly going out of fashion, and it is ceasing to be considered a disease of the mind *per se*. This change of belief implies no irreverence towards God's special providence, but a growing opinion that many peculiarities of modern civilization are sufficiently antagonistic to the laws of nature to render unstable that normal balance between the mind and the body which almost invariably exists in savage nations. Providing that the body is well nourished and the brain well worked, there appears to be no increase of mental alienation in spite of mercantile disaster and political changes. Let long years of unrequited toil, insufficient and improper nourishment, be passed amongst all that degrades humanity, and the improperly educated brain will become unhinged by an unusual series of exertions. Civilized poverty is the hotbed of insanity and of a type which is singularly irremediable. It follows that whilst moral management may be necessary for some lunatics, a special physical treatment which must bear a definite reference to the constitutional causes of the ailment is absolutely required for the majority. This method of treatment cannot be obtained under the present system of seclusion in asylums where the success in re-establishing reason is not greater than it was when all the horrors of the madhouse were in full force, but it may be successfully carried out under an intelligent supervision, adapted to the village and cottage system foreshadowed by the insane colony of Gheel.

III. THE METALLURGICAL INDUSTRY OF CLEVELAND.

THROUGHOUT the whole history of applied science and the metallurgic arts there is probably nothing which can at all compare with the condition of things now prevailing in Cleveland. In the more limited acceptation of the term, Cleveland is, strictly speaking, but a small portion of the North Riding of Yorkshire,—probably about one-third of it; but, from the fact that the staple industry is the same throughout a large part of Teesdale and South Durham as in Cleveland proper, the term has now popularly acquired a more extended signification. Within a very limited area of the district referred to, the last twenty years have seen an industrial development which has no equal, either in ancient or in modern



1.—The First Age of Iron-making.



2.—The Second Age of Iron-making.

times, at home or abroad. It has been extraordinary, in every sense of that term. It is true that in the minds of many persons who have no practical acquaintance with Cleveland, there is always associated with that name the idea of iron-making; but to the million, and even to many well-educated people, it conveys practically no idea whatever, unless it be of the crudest description. It is not highly improbable that some of the examiners for the Civil Service would themselves fail to pass an examination in the physical and political geography of Cleveland; certain it is, however, that some of their best examinees would be "plucked" if examined on the subject. And yet, while such a great amount of ignorance prevails regarding Cleveland, it is already the greatest iron-making district in this country or in the whole world; and while being the greatest, it is practically the youngest seat of the iron-smelter's art in Britain, that is, if it be compared with South Staffordshire, South Wales, and Scotland.

As there must be some special circumstances to which that remarkable pre-eminence is due, it will be the object of this paper to attempt to trace them out and enlarge upon them. It may be premised that an unusual amount of attention was directed to Cleveland in the autumn of last year, both by the iron and steel trades of the country and by the public at large, owing to the fact that the first provincial meeting of a new scientific association, bearing the name of the Iron and Steel Institute, was then held at Middlesbrough, the capital of Cleveland. That organization had only been formally ushered into existence at the preceding midsummer, by the delivery of the inaugural address of the President, the Duke of Devonshire, the great ironmaster of Barrow-in-Furness; and yet at the time of the meeting referred to it included nearly 300 members, many of them being the most extensive and the most scientific ironmasters and steel-makers in the kingdom. Its success was so great, that there was no room for doubting the wisdom of the suggestion which first gave birth to the Iron and Steel Institute. The originator of the idea was Mr. John Jones, F.G.S., the secretary for the North of England Iron Trade, and now likewise the secretary for the new association, the objects of which were, first, to afford a means of communication between members of the iron and steel trades upon all such matters as bear upon the respective manufactures, and are not connected with trade regulations and wages; and, second, to hold periodical meetings for the purpose of discussing practical and scientific subjects relating to the manufacture and working of iron and steel. Owing to the vast amount of interest, both industrial and scientific, associated with Cleveland, it was highly proper that the first provincial meeting of the Institute should be held at Middlesbrough. It brought together many persons to whom Cleveland was practically a *terra incognita*, and every facility was freely

offered to them for the exploration of the district, so that they might have an opportunity of studying those features which had given to the district a history which, though brief, is perhaps the most eventful and interesting in the whole annals of the iron manufacture.

That history may be said, in a measure, to have commenced in the year 1829, when the site of modern Middlesbrough was chosen as a coal-exporting place, owing to its closer proximity to the sea than the town of Stockton, which was then the eastern terminus of the famous Stockton and Darlington Railway, by means of which the South Durham coal-field was connected with the river Tees. Since then the district of Cleveland and its capital, Middlesbrough, have had a most extraordinary career, and have acquired a wonderful importance, whether regarded from a social, industrial, or scientific point of view. About the time just mentioned the site of Middlesbrough had only one solitary farmhouse, while at the present time the municipal borough and its immediate belongings contain a population of about 50,000 inhabitants.

While the first stage of Middlesbrough history commenced in 1829, as already mentioned, the connection of the town with the great national industry of iron-making only began in the year 1840–41, when a rolling-mill and other works were erected for the manufacture of malleable iron on a small scale by Mr. Bolckow and the late Mr. John Vaughan. The former is a German, a native of Mecklenburg, and the latter was a man of indomitable perseverance and unflinching industry, whose practical acquaintance with iron-making had been gained while he was a workman at the world-famous ironworks of Dowlais, South Wales. At the time just mentioned, and for some four or five years longer, Messrs. Bolckow and Vaughan brought their pig-iron from a distance and transformed it into bars, rails, castings, &c.; but in the year 1845 or 1846 they erected several small blast furnaces at Witton Park, near Bishop Auckland, where they expected to secure a suitable supply of ironstone to keep their furnaces employed. The supply soon failed, and then they resorted to what was then known as Whitby ironstone, which they obtained on the Yorkshire coast, at Skinningrove, some ten or twelve miles from Whitby. For a time they continued to work this Skinningrove ironstone, and carry it by ship and by rail, and at considerable expense, all the way to Witton Park to be smelted.

The third period of the history of Middlesbrough and Cleveland began about the end of the year 1850, when the town of Middlesbrough had a population of not more than 7000 inhabitants. It began with the discovery of the same deposit of ironstone almost as far inland from Skinningrove as Skinningrove is distant from Whitby, and quite within sight of Middlesbrough.

The difficulties of shipment were so great, owing to the exposed nature of the coast, that it was deemed very desirable to make a careful examination of the geological structure of the Cleveland Hills. It was in the year just mentioned that the search for the mineral proved successful, and the discovery has been the most eventful circumstance in the history of Cleveland. From the circumstance that the mineral was discovered there, it has since been known by the name of the Cleveland ironstone. Claims have been urged on the part of various persons as the discoverers of this famous mineral, as it has already, within the short period of twenty years, been largely concerned in effecting a great revolution in iron metallurgy. It is not desirable to make any effort in this place to settle those claims; and, indeed, as the Whitby and Cleveland ironstone are one and the same mineral deposit, and as the mineral was certainly known in the year 1822, when it was spoken of in Young and Bird's 'Yorkshire Coast,' and more fully described by Phillips in his 'Geology of Yorkshire,' published in 1835, it would practically be impossible to decide who was *the* discoverer of the mineral. Referring to this subject in his paper "On the Cleveland Ironstone," read before the South Wales Institute of Engineers, in August, 1869, Mr. Thomas Allison says, "Whoever was the first discoverer, the German Ocean may, we think, with justice, be said to have been the first miner, by undermining and denuding the Lias cliffs of the Yorkshire coast, containing the main bed of ironstone, strewing the sea-beach with large blocks of the ore, which, like lobsters boiled, changed their colour to red by billowy and atmospheric influence, while the shaly part of the denuded cliffs was, by the same causes, pulverized and washed away."

The ironstone thus mined on the sea-coast was shipped in large quantities to the ironworks on the Tyne and Wear for a number of years before it was discovered inland. It is even stated that some of it was sent to the Tyne as far back as the year 1811. This, however, is certain, that John Vaughan was the first man to recognize the great industrial value of the inland deposits of Cleveland ironstone, and that to his practical knowledge is due not only the tentative introduction of the ironstone in 1850–51, but the present enormous development of the Cleveland iron trade, based, as it is, on the utilization of those immense deposits of ore.

After the employment by Mr. Vaughan of portions of the ironstone deposit of the Cleveland Hills, its enormous extent began to dawn upon the minds of geologists and mining engineers; and since then its distribution, position, and extent have been most carefully determined by Messrs. Marley, Bewick, Cockburn, Allison, and others. It is stating the facts in a very prosaic way to say that the Cleveland ironstone is deposited in such an enormous quantity as to be practically inexhaustible, and that the mining operations

are now conducted upon a most gigantic scale. A few details bearing on these points may not be out of place at this stage.

The ironstone of Cleveland is an impure carbonate, but it does not belong to the Carboniferous series of strata, as do the blackbands and the argillaceous or clayband ironstones. It occurs in some nine or ten seams, distributed chiefly through the Middle Lias group of the Oölitic series; but they are not all worked, nor, from a commercial point of view, are they all workable. The chief source of the ironstone which is at present being worked is the Main Cleveland Seam, the thickness of which is sometimes from 17½ to 20 feet, as at the Eston mines. At other mines it varies from this extraordinary thickness down to 15, 11, and even to 7 feet. At the Eston mines the ore is worked at a depth of nearly 600 feet from the top of the shaft, which opens out on a bleak and uninhabited Yorkshire moor. Sometimes the main seam is split up into two seams by shale and other beds, the upper being distinguished palæontologically as the *pecten* seam, and the lower as the *avicular* seam. Where the main seam is undivided it is generally richer in metallic iron than where it is split into two seams: in the former case the ore may yield from 30 to 31 per cent. of metal, while in the latter the yield is frequently from 28 to 26 per cent. of metallic iron. Cleveland ironstone is highly fossiliferous—indeed, it may be said to be quite charged with animal remains, and consequently there always occurs in the iron extracted from it a notable quantity of phosphorus, the presence of which has hitherto rendered the production of steel from it, without puddling, a scientific impossibility. Analyses of Cleveland pig-iron give not unfrequently from 1·2 to 1·3 per cent. of this troublesome element; and yet, although it is generally regarded as an undesirable ingredient of manufactured iron, it would almost seem that Cleveland iron, in the form of railway bars, has a greater degree of durability than iron which is practically free from phosphorus. Besides the seam referred to—the Main Cleveland Seam—there is another workable seam, known as the Top Bed. Geologically, it is from 230 to 250 feet higher up, resting on the top of the Upper Lias, the chief feature of which is the well-known Whitby alum shale. This Top Bed is only worked at three places—Glaisdale, Rosedale, and Port Mulgrave, on the coast. At Rosedale there is also a peculiarly deposited bed of rich magnetic ironstone, occupying the same geological position as the Top Bed just spoken of. It sometimes yields as much as 49 per cent. of metallic iron.

In a number of places throughout Cleveland the ironstone deposit has been completely removed by denudation. The total extent of the denuded area is about sixty square miles, but even after making allowance for that fact there is an iron-bearing area of about 420 square miles. In one portion of that area the deposit

amounts to about 27,000 tons per acre; and in another, where the ore may be said to be of second-class quality, the yield is almost 18,000 tons per acre. The total amount of ironstone obtainable from the Cleveland Hills is, therefore, upwards of 4,500,000,000 tons, an amount so great that one can scarcely form an adequate conception of it. According to the calculations of Mr. William Cockburn, mining engineer at Messrs. Pease's Upleatham mines, the total yielding power of the mines throughout the Cleveland district is now upwards of 5,000,000 tons per annum; and according to the same gentleman's calculations the mineral of the first quality may be expected to last seventy-three years, while that which he considers to be of the second class is almost inexhaustible. It is to be hoped, but hardly to be expected, that the South Durham coal-field will hold out long enough to supply the heating power to calcine and smelt the ironstone which Nature has so bountifully deposited in the Cleveland Hills.

At first the Cleveland ironstone was generally quarried where it cropped out on the surface, but the plan now adopted is to sink shafts from the surface or drive levels from the hill-side, or both, and then work the mineral upon the "bord and pillar" principle. Some of the iron-smelting firms have mines of their own, others contract for their supply of mineral. As the mining operations of Cleveland are conducted upon such a gigantic scale, it is but natural to expect that no antiquated measures are adopted unless their utility has been fully demonstrated. To be "time-honoured" is not alone sufficient; they must be the most economical methods of procedure, both as regards the mineral to be worked and the labour and life spent upon it. One finds in use the most highly approved mechanical appliances, both for "winning" the mineral and for draining and ventilating the mines. As a single illustration it may be mentioned that in one of the mines explored by the present writer—one belonging to Messrs. Bolckow, Vaughan, and Co. (Limited), at Eston—the engine-plane was brilliantly illuminated throughout nearly a mile and a half with coal gas. The same plane is a level or drift which serves as an air-course inwards and a water-course outwards. The water is drained from the mine at the rate of about 600 gallons per minute, and is carried by gravitation to the company's blast furnaces, where it takes the place of water which formerly cost 1000*l.* per annum.

The ironstone, which is the raw material forming the prime requisite of the great industry of Cleveland, is obtained so cheaply that it can be laid down at the furnaces at a cost of 4*s.* to 4*s.* 6*d.* per ton; and as it contains very frequently from 28 to 31 per cent. of metallic iron, the ore for a ton of pig-iron costs less than 14*s.* It is in a very great measure owing to the extraordinary abundance and cheapness of the raw ironstone that the Cleveland

ironmasters have, in a comparatively short term of years, acquired for their district the proud distinction of being the greatest seat of the iron manufacture in the whole world.

It was in the month of September, 1850, that the first sample of Cleveland ironstone from the Eston Hill was smelted at the Witton Park Iron Works; but it was only a few months afterwards that active measures were taken for the practical treatment of the mineral at Middlesbrough, within easy reach of the ironstone deposit. Messrs. Bolckow and Vaughan were the first firm of ironmasters to enter upon the Cleveland industry. They were the first to erect blast furnaces on Tees-side, and were really the original pioneers of the present gigantic trade of the district. But there were other firms who soon cast in their lot with Messrs. Bolckow and Vaughan by erecting blast furnaces in the district. Chief among these, it is but proper that mention should be made of Messrs. Bell Brothers, of Clarence Iron Works, Messrs. Gilkes and Wilson, Messrs. Cochrane, and Mr. B. Samuelson, M.P. They were keenly alive to the great resources of the district, and they brought great practical and scientific abilities and commercial energy to bear upon those resources. Their example has since been followed in a most remarkable manner, and the energy which has since been displayed has been most wonderful, if not even unique, if one may judge by comparing the state of things now prevailing with that which existed twenty, fifteen, or even ten years ago—for even within the last five years or so, the ironworks of Middlesbrough and its immediate vicinity have been nearly doubled in number.

As already indicated, the chief or primary circumstance to which this extraordinary scientifico-industrial development is traceable is the almost inexhaustible store of comparatively rich ironstone lying quite at hand in the Cleveland Hills; but there are other circumstances which must also be taken into consideration. A sojourner in the district can scarcely fail to be struck with the wonders that surround him on all hands. To a few of the circumstances which strike a stranger to Cleveland—but who is not a stranger to the iron trade—reference may now be made.

I. *Calcining Kilns.*—In the Cleveland district the ironstone is in some instances calcined before leaving the mines, but in most cases it is calcined in very close proximity to the blast furnaces where it is to be smelted. The operation is effected in calcining kilns, never in open heaps or "bings," such as may be seen in various iron districts. These kilns have no very distant resemblance to lime-kilns. They are generally of very considerable size, sometimes fifty feet in height, and upwards of twenty in width; indeed, they are frequently a good deal larger than many of the blast furnaces of South Staffordshire, South Wales, and Lanarkshire. The raw ironstone is raised to the top of the stacks of calcining

kilns, either by inclined planes up which the laden waggons are dragged, or by hoists of great ingenuity. As a rule, it is thoroughly roasted or calcined by means of one ton of small coal or "breeze" to from thirty to forty tons of green ironstone. In every direction labour-saving appliances are to be found. Even in the discharging of the kilns an ingenious hopper arrangement has been applied, which economizes labour to a remarkable extent. The roasted stone is charged into great iron barrows without any shovelling being required, and by means of them it is lifted in the furnace-hoists to the top of the furnace, and charged into them quite hot. This plan of charging the furnaces with calcined ore while it is dry and quite hot also effects some economy in the fuel.

II. *The Blast Furnaces: their Number, Size, and Mode of Working.*—The blast furnaces of Cleveland form quite an extraordinary feature throughout the whole district, whether we regard their number or their size, or the mode of working them. In no other iron-making district can such a sight be seen as that which meets the eye of the visitor to Middlesbrough and the district immediately surrounding it. At the present time (February, 1870) there are no fewer than 122 blast furnaces in the Cleveland district, if under that term it may be permitted to include Durham, considering that Cleveland ironstone is almost universally used in the blast furnaces of that county. True, there are twelve of that number of furnaces that are not likely ever to be again brought into use in their present form, as they are too antiquated, and not in accordance with the prevailing notions as to what a blast furnace should be. Then there are other nine which are out of use, but as they are available they may again be called into requisition. There are thus left 101 furnaces, all of which are in blast; but besides these there are fourteen new ones being built, one being raised, and other two being rebuilt or modernized. Somewhere about seventy, or about two-thirds of the whole, are clustered within an area so limited that a radius of three or four miles from the centre of Middlesbrough would include almost every one of them.

And then, such furnaces as they are in point of size, almost universally! Throughout Monmouthshire and South Wales there are probably not fewer than 200 blast furnaces, while out of that great number only four or five reach to a greater height than 50 feet. Many of them are only 35 or 40 feet high, and there is even one that rises no higher than 25 feet. In South Staffordshire from 45 to 50 feet is the commonest height for the blast furnaces, and in Scotland the greater of those two elevations is but seldom exceeded. But what a mighty difference is observable throughout Cleveland. Such a puny thing as a furnace only 45 feet high is exceedingly rare, and in comparison with many of the other colossal structures it might almost be spoken of simply as a crucible or a tiny

smelting-pot. Heights of from 70 to 95 feet are common throughout the whole district, while at Ferryhill there is one furnace that towers up to the extraordinary height of 103 feet, and is therefore, doubtless, the most gigantic iron-smelting furnace in the world. In the short space of twenty years Cleveland blast-furnace practice has passed through several phases. At first the furnaces were built only 45 feet high, then the height was increased to 56 feet, next to 60 feet, and then (in 1863) to 75 feet, and soon afterwards still greater heights were adopted. Some of them had but very short lives comparatively; they were erected and in use but a few years when it was resolved to raze them to the ground, and rebuild them of much larger dimensions. Amongst the new furnaces now in course of erection it is stated that there are two which are to be built to the height of 90 feet; and even the great furnace at Ferryhill is to be overtopped by one which is to reach a height of 120 feet! And as is the height of the Cleveland furnaces so is their internal diameter at the widest part, or what is technically known as the "boshes." It generally varies from 16 to 25 feet, but in the case of the Ferryhill furnace it is 27 feet. The two 90-feet furnaces just referred to are to be 30 feet wide at the boshes, or one-third of the height; and it is proposed to make the 120-feet furnace no less than 33 feet wide at the boshes. Were the Vulcans and Tubal Cains of antiquity to revisit the earth, they would doubtless stare on coming within sight of these immense smelting crucibles.

When compared with such primitive furnaces as are still in use in Central Africa, as represented in the first of our sketches illustrating "the ages of iron-making" (see Plate I.), the contrast is remarkable in the extreme. It is even still remarkable when such a blast furnace as is in use at Mariedam, in Sweden (Plate II.), is compared with one of the modern or Cleveland type, as illustrated in Plate III.

The internal capacity of some of the Cleveland furnaces amounts to 25,000 or 26,000 cubic feet—that of the Ferryhill furnace being 33,000 feet; and the weekly production of pig-iron from a number of the furnaces—fourteen castings, or two daily—is from 420 to 450 tons; at Norton it is as much as 550 tons. A single casting from one of the Ormesby furnaces has been known to weigh 45 tons. With furnaces which, together with their great number, have such a prodigious yielding power, it is scarcely to be wondered at that the Cleveland ironmasters are now making nearly one-third of all the pig-iron produced in Great Britain. One of them is the greatest individual maker of pig-iron in the world, namely, Mr. Thomas Vaughan, of Clay Lane and South Bank Iron Works. His annual make is nearly a quarter-million tons.

For a considerable length of time a vigorous and interesting

discussion has been going on amongst the Cleveland ironmasters with reference to the maximum dimensions that may be allowed in the blast furnaces consistent with a due regard to the highest degree of scientific economy in the working of the same. Mr. Isaac Lowthian Bell, who may perhaps be justly regarded as the greatest authority in the science and practice of iron-making amongst practical ironmasters, has taken his stand after having instituted probably the most elaborate series of experiments in blast-furnace practice ever made. The paper which he read at the Middlesbrough meeting of the Iron and Steel Institute, "On the Development of Heat and its Appropriation in Blast Furnaces of different Dimensions," treats the subject very exhaustively. Mr. Bell obtained his data for calculation from furnaces of almost all capacities, ranging between 3500 and 33,000 cubic feet, and his verdict was that the most economical furnaces would ultimately prove to be those having capacities ranging from 12,000 to 25,000 or 26,000 cubic feet. There are, however, many ironmasters and blast-furnace managers who do not agree with the dictum pronounced by Mr. Bell, and there is a great deal to be said in favour of the assumption that the maximum limits have not yet been reached. In the opinion of Mr. C. W. Siemens, F.R.S., great results must be looked for rather by increase in the temperature of the blast than by simply increasing the capacity or height of the furnace. As a rule, every increase hitherto made in the heights of blast furnaces has been attended with a saving of fuel, not in Cleveland only but in other iron districts also. For instance, by raising the height of some of the cold-blast furnaces at the Lilleshall Iron Works, Shropshire, from 50 to 70 feet, there was a saving of seven or eight cwt. of coal per ton of iron made.

The Cleveland furnaces present a remarkably strange appearance to one who has been much accustomed to the iron-smelting furnaces of the older iron districts. Elsewhere, as in many parts of the "Black Country," Wales, and Ayrshire and Lanarkshire, the furnaces are almost all provided with open tops from which great tongues of flame are constantly belching forth, together with enormous volumes of smoke, indicating prodigal waste of fuel; in Cleveland, however, all the furnaces are close-topped, and the gases generated in the interior are collected and utilized. In the Cleveland iron-smelter's vocabulary the term "waste gases" is unknown. According to Mr. Bell,* the system now in operation in Cleveland effects a saving of something like 600,000 tons of coal per annum in those works smelting the ironstone of North Yorkshire. Such scientific economy cannot fail to have important social and political considerations. The mode of closing the furnaces is generally the

* Paper read before the Chemical Society of London. 'Journal of the Chemical Society,' June, 1869.

same in principle throughout the whole district: it is the well-known hopper-and-cone arrangement; and the gases are drawn off very near the top of the furnace, and conducted away by means of capacious tubes to be used in generating steam and in heating the air of the blast. Theoretically, there should be no coal used in either of these operations; they should both be accomplished by means of the furnace gases, and in practice this state of perfection is fully reached at some of the works.* As coke is the fuel used in Cleveland, the combustible gas which is generated consists almost entirely of carbonic oxide, and it is the calorific power of this gas which the iron-smelter has to utilize. Of course, there is also the atmospheric nitrogen of the air of the blast passing through the furnace. Of necessity, it absorbs a vast amount of heat, but of this heat it is well deprived before it is thrown back into the atmosphere.

Since the hopper-and-cone arrangement of closing the furnace-top was generally adopted throughout Cleveland, it has been very materially improved, especially by Mr. Charles Cochrane, of the Ormesby Iron Works, Middlesbrough, a gentleman who is now one of the most active spirits in suggesting and applying improvements in blast-furnace practice. Within the last few years he has contributed no fewer than five papers on various phases of blast-furnace economy to the 'Proceedings of the Institution of Mechanical Engineers,' and all of them have been marked by indefatigable perseverance and by great practical and scientific attainments. His improved arrangement is that of the double-closed furnace-top, and has for its object the diminution of the amount of gas escaping from the furnace at the time of charging. It has done this so effectually that for one furnace the saving in fuel alone is equal to about 164*l.* per annum, while the necessary apparatus only costs 200*l.*

In the hands of the Cleveland ironmasters the great invention which was given to the world by James Beaumont Neilson, namely, the hot-blast, has of late almost revolutionized even Cleveland iron-smelting. Neilson seemed to think that he had arrived at the acme of perfection when he got the temperature of the blast raised to about 600° Fahrenheit; and in Scotland, where the invention had its birth, the blast is rarely heated much beyond that temperature. But in Cleveland, where no such deference is paid to old customs and traditions as they receive in Scotland and in South Staffordshire, there seems to be no resting-place. Improvement succeeds improvement with extraordinary rapidity, and at present it is in the direction of increased temperature in the blast rather than in increase of furnace capacity that further economy is to be sought for. It is

* At Mr. Samuelson's Newport furnaces no coal whatever has been used for several months.

no uncommon thing in Cleveland to find the blast heated to from 850° to 1000° Fahrenheit, but even the greater of those temperatures is not deemed sufficient. Under the leadership of Mr. Cochrane the tendency is still upwards. That gentleman has applied at the Ormesby Works the Siemens' regenerative system as adapted by Mr. E. A. Cowper, C.E., F.R.S., for the heating of the air of the blast. He has of late used the blast at the unprecedented temperature of 1452° Fahrenheit, and the result of his experience is that for each 100° that the blast is raised there is a saving of 1·34 cwt. of coke per ton of iron made. It is the opinion of Mr. Bell that 21 cwt. of coke per ton of pig-iron is about the lowest minimum that can be attained, but Mr. Cochrane is sanguine that a minimum of 13 cwt. can be reached, provided that the blast is heated up to 2000°, and he has determined to aim at reaching that minimum consumption of coke unless experience should prove it to be impossible to attain it. Even a consumption of only 21 cwt. of coke per ton of pig-iron must be deemed very marvellous, when it is remembered that twice that amount is employed in producing a ton of iron in cold-blast furnaces. There are instances of furnaces in the Cleveland district—Consett and Ferryhill—working on a consumption of 17 or 18 cwt. of coke per ton of pig-iron, but they are somewhat exceptional, as the ironstone used was either the rich Rosedale stone or not exclusively Cleveland stone, but a mixture of it with hæmatite, and therefore containing at first a much larger proportion of metallic iron than is customary throughout the district. Superheated air is also in use at Consett Iron Works, the temperature of the blast being about 1400° Fahrenheit, and produced in a hot-blast stove, which is a modification and simplification of the Siemens-Cowper stove in use at the Ormesby Works. Report speaks of it very favourably as a fuel-saving appliance. The inventor of it is Mr. Thomas Whitwell, of the Thornaby Iron Works, Stockton.

Various other appliances and improvements have been brought to bear by the Cleveland ironmasters upon the great industry in which they are engaged. By the use of separate heaters, water is generally fed into the boilers in a boiling condition or nearly so. Furnace materials have to be lifted to such vast heights that hoists of almost every conceivable variety have been devised and brought into use;—the water-balance hoist, the vacuum hoist, the air-pressure hoist, and the water-column hoist, may all be mentioned as exhibiting special meritorious features of engineering construction.

From the facts already alluded to, and on account of the interesting scientific and practical problems which are at present being worked out, the eyes of all iron-making districts are anxiously directed to Cleveland. It is iron-smelting which really forms the staple industry of that district, and although it is scarcely twenty years since it had its very small beginning, it is already of such enormous pro-

portions that every other district is completely overshadowed by it. But although iron-smelting is *the* staple industry of Cleveland, it is not the only one. The manufacture of malleable iron is carried on to an immense extent throughout the district with great skill and energy, and it has called into requisition some 1400 or 1500 puddling furnaces, possibly even more: and some of those furnaces are amongst the most economically effective appliances known to the metallurgist. In some of these the consumption of coal per ton of puddled bar has been reduced from 25 to 15 cwt. It was in Cleveland, likewise, that works were first erected by Messrs. B. Samuelson and Co. for the practical application of the Siemens-Martin process of manufacturing steel; and the experiments made by that firm at the Newport Works would seem to indicate that there is a great degree of probability that steel ingots for rails may yet be made at a price little exceeding that of puddled bar. This is not the place to enlarge upon the fact, but it may be stated that in the Cleveland iron trade two great social problems have been solved, namely,—1. The prevention of strikes and lock-outs, by the establishment of the Board of Arbitration and Conciliation; and, 2. The possibility of the co-operative system being carried out in a large iron-making establishment,—the employés participating with the capitalists in the division of the net profits of the business. This system has been in operation during three years at the works of Messrs. Fox, Head, and Co., and it has just been resolved to continue the arrangement for the next five years.

Great scientific and industrial results have been accomplished by Cleveland already, but it is not too much to expect that she has in store other equally great, if not even greater, triumphs for the historian to record.

The production of rails in Cleveland is at the present time not far short of 750,000 tons, and probably three-fourths of all the iron-plates used in shipbuilding are made from Cleveland iron.

The readers of this Journal will recollect that brine-springs have been found under the town of Middlesbrough; and there is every likelihood of the manufacture of salt being added before long to the other industries of Cleveland.

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2. *Proceedings of the Cleveland Institution of Engineers.* November, 1869.
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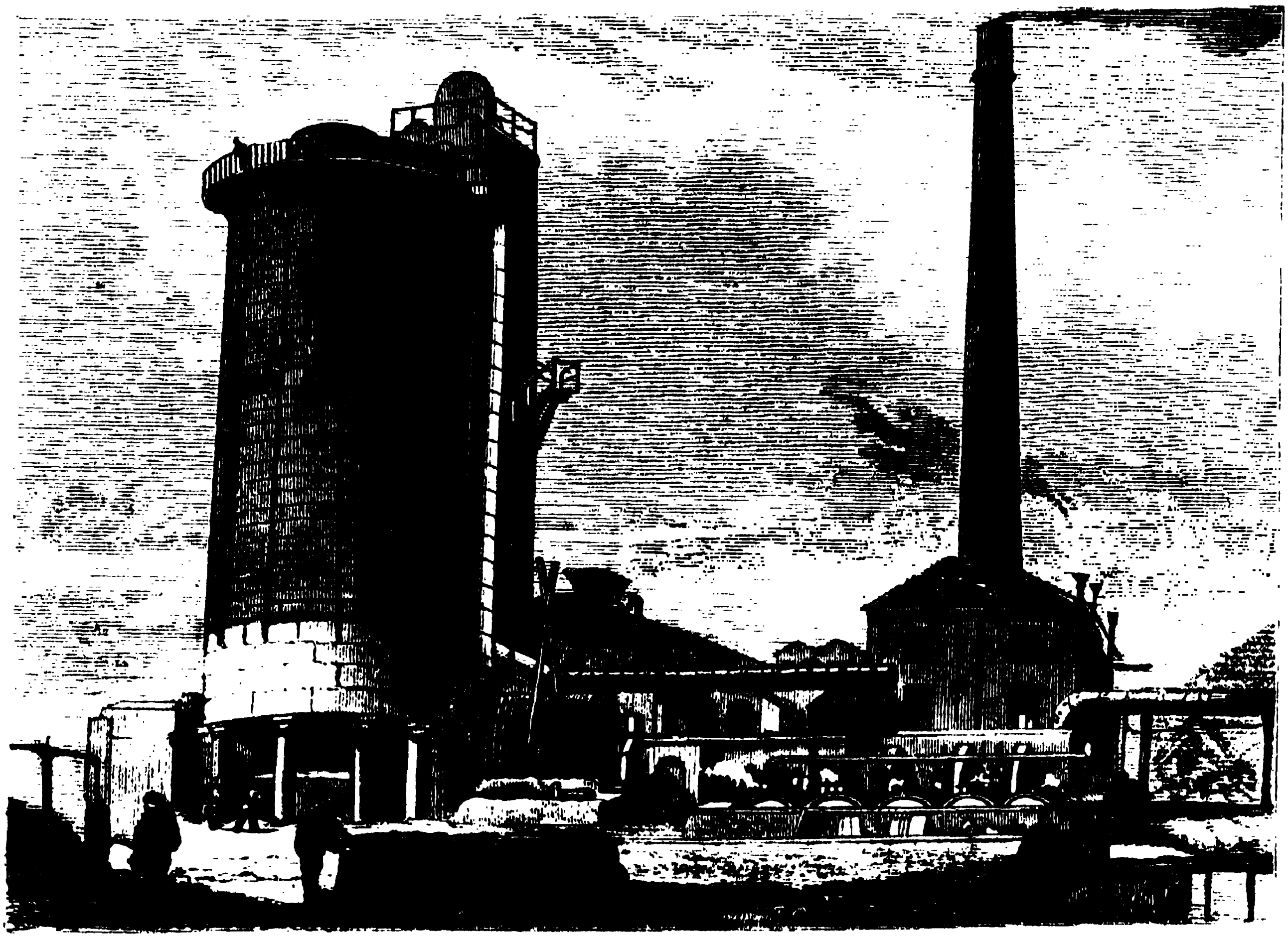

3.—Third, or Cleveland Age of Iron-making.

4.—Death of an Ironworks.

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5. "On Our Foreign Competitors in the Iron Trade:" A Paper read to the North of England Ironmasters, by I. Lowthian Bell. 29th September, 1868.
6. "The Chemistry of the Blast Furnace:" A Lecture delivered to the Chemical Society of London, by I. Lowthian Bell. 1869.
7. *Transactions of the Iron and Steel Institute.* Session 1869.
8. *The Industries of the Tyne, Wear, and Tees.* 2nd edition. Longmans.

DESCRIPTION OF THE XYLOGRAPHIC PLATES.*

I.—First Age of Iron-making.—A pen-and-ink sketch, made by Captain Grant, who accompanied Speke to Lake Nyanza. It represents native Africans making malleable iron direct from the ore. The ore is placed in the low charcoal fire, and a man on each side urges it by means of bellows (two single-acting—that is, four single-acting in all), so as to keep up a continuous blast.

II.—Second Age of Iron-making.—Illustrated by the blast furnace at Mariedam, in Sweden, where the low hearth has passed through the intermediate stage of the *blauofen*, and arrived at the high or true blast furnace for the manufacture of pig-iron. Height, about 40 feet; built of rough stones bound together by logs of timber painted red; using charcoal, and making from thirty to forty tons per week during four or five months in the year.

III.—Third or Cleveland Age of Iron-making.—Illustrated by the Wear Furnace at Washington, co. Durham. This furnace makes about 330 to 350 tons of iron per week from coke made on the spot, the heat from the coke ovens being used for heating the blast. The furnace gases are also partially used for this purpose, for raising steam for the blast engine, and for boiling down certain solutions in the adjoining chemical works. The exhaust steam from the engines heats up a large quantity of water required in the chemical works. The ore smelted is the Cleveland stone, with a small quantity of residual oxide of iron from the chemical works, nothing being wasted.

IV.—Death of an Ironworks.—This sketch represents two furnaces, built on a landslip, on the Yorkshire coast. After the works were finished, the land slipped a little further, and reduced the place to a ruin within two months. The owners, nothing daunted, rebuilt the works, and a second ruin resulted from the total absence of ordinary judgment shown in building on such a site.

* The photographs for these plates have been kindly contributed by I. Lowthian Bell, Esq.

IV. ON "TROPHIC NERVES."

By GEORGE ROLLESTON, M.D., F.R.S., Linacre Professor of Anatomy and Physiology, Oxford.

ALL physiologists, and indeed all observers, whether physiologists or not, are agreed that the nervous system intervenes most powerfully, and that not rarely, in controlling and modifying the processes of what we call "organic life." Growth and development, it is true, may be carried on, food may be assimilated, and secretions may be elaborated, independently of nerves and nerve-centres in many lower animals; but, on the other hand, it is equally true that in more highly organized creatures there are but few processes of vegetable life which may not be, at times and to a greater or less degree, brought under the influence of their cerebro-spinal systems. As to the facts, there is no question; as to the way in which the facts are brought about, however, there is a very wide difference of opinion. This difference is expressed in the contradictory answers given by representatives of various biological schools to such questions as:—Can the nerves act directly upon cells other than muscular fibre cells? Can nerve-force interfere with the cell territory otherwise than by regulating the stream of nutriment brought within the borders of that territory by the blood-vessels? Are there, finally, "trophic" and secretory as well as vasomotor nerves? The indirect action of nerves upon tissues in the way of vasomotor regulation of the blood-vessels supplying them is more readily comprehensible by us, but that nerves can act directly upon cells pigmentary, secretory, and other cells, as well as upon contractile cells and fibres, appears to the present writer all but equally demonstrable. Change of colour in ourselves is usually dependent upon vasomotor change; but change of colour in the frog has been most conclusively shown by Professor Lister to be dependent upon molecular movements carried on in the interior of cells under the influence of the nervous, and under circumstances which exclude the intervention of the blood-vascular system. A force which can be seen to produce molecular movement within a pigment cell, may well be supposed to be competent to produce nutritional or chemical changes in the interior of cells of other characters. But if our knowledge of the convertibility of force makes us ready to allow that nerve-force may show itself by modifying nutrition or by producing secretion as well as by producing motion, our knowledge of the convertibility of function which nerves possess accordingly as they are distributed in one or in another class of tissues makes us slow to accept as a necessity the establishment of a division of "trophic" nerves. Messrs. G. H. Lewes, Philippeaux, and Vulpian have shown that nerves are sensory

or motor accordingly as they are distributed to sensory or contractile tissue-elements, and not by virtue of any inherent differences in their own structure; and if we have thus to modify our views, if not as to the use of the words sensory and motor nerves, at all events as to the meanings we attach to them, it would be doubly inexpedient to introduce now new words, "trophic" and secretory; considering, firstly, that they are not old and familiar to us, nor possessed therefore of a claim upon our toleration; and, secondly, that they labour under just the same disadvantage of needing to be used with a mental qualification as the older words in question. This is, however, but a question of words; and it may be well now first to state the facts so far as they appear to have been ascertained by observation and experiment; and then, in the second place, to suggest, or leave the reader to excogitate for himself, such a reading of them as may seem best fitted to bind them together into a bundle easy to be manipulated by the mental hand.

I will begin by giving a few facts which bear directly enough upon the influence exercised by psychical changes and cerebral affections upon processes of vegetative life, but which do not give any clear indication as to the way, whether vasomotor or intracellular, in which that influence is brought directly to bear. Facts of what some persons would call great generality, but what others would, and with greater propriety, call great complexity, are presented to us in the familiar histories of defeated armies and of other bodies of men subjected to depressing psychical influences. Such aggregations of men are found to be more liable to succumb to various unhealthy influences, such as those of dysentery, scorbutus, and malaria, than are other aggregations of men similarly constituted except as to their mental impressions or depression. But *in generalibus latet error*; and as we have exact quantitative observations, showing that prisoners in civil gaols perform the ordinary functions of life less perfectly, and at greater cost to their own organism, as also to that of the body politic, than do honest, or, to use the safer term suggested to me by a warder in Portland prison, *unconvicted* men, we had better refer to them. These observations will be found recorded in the Report of the British Association Meeting held in Manchester in the year 1861, at p. 59, and, *passim*, in a "Report on the Action of Prison Diet and Discipline on the Bodily Functions of Prisoners," which we owe to Dr. Edward Smith, F.R.S., and Mr. W. R. Milner. The "cerebral exhaustion," again, so common in these days of stress and tension, is well known (as well it may be, considering what abundant opportunities we have for observing it) to exercise a similarly "atrophic" influence. Modern language, indeed, by altering the meaning of the word *indolence* from that of *freedom from pain* to that of *freedom from labour*, appears to show us that the real relation of *overwork* to *disease* has been more or less obscurely

recognized by the laity, even at times when the faculty inverted the relations of effect and cause which really do exist between many manifestations of mal-nutrition, such as dyspepsia and cystitis, on the one side, and cerebral overwork and spinal exhaustion on the other. It is to Dr. Gull* that we owe a demonstration of the facts that the painful affections specified, as well as others only alluded to, are antecedents, but in the sense in which a man's shadow antecedes him when the sun is at his back; that the doctrine of reflex paraplegia was wrongly applied to those cases; and that they are really to be explained as being of the same character as those furnished to us in the histories of men subjected, in prison, as if in an experiment, to the working of mental depression.

Simpler cases still are furnished to us by the well-authenticated accounts of persons losing all their hair after cerebral injury.† When we consider how large an organ the brain is relatively to the rest of the body, and how, protected as it is by its lodgment within an air-tight cavity, it can say to all other organs of the body, "Thou shalt want before I shall," there is no need to waste time in imagining how its derangement may and must entail derangement throughout the entire body. It may be profitable to discover by investigation how this secondary derangement is brought about, whether indirectly by vasomotor alteration, or directly by molecular disturbance set up intracellularly. At present the necessary investigations have not been set on foot; and, *ad interim*, we may colligate the facts under Mr. Darwin's expression of "correlation of growth."

We come in the third place to cases of greater simplicity still; and by this we do appear at first sight to be brought within the sphere of the explanation which the phrase "Trophic nerves" implies. These cases are constituted by the accidental severances of nerves which take place in civil, and more especially in military life, the musculo-spiral nerve, whence the greater part of the thumb and lesser proportions of the three fingers next to it receive their dorsal supply, being specially well fitted for such experimentation, and specially obnoxious to it in the "pious pastime" of war. Dr. S. Weir Mitchell has put on record, in 'The Contributions relating to the Causation and Prevention of Disease, and to Camp Diseases,' edited by Dr. Austin Flint, and published by the United States' Sanitary Commission, some very valuable observations as to the effects of such injuries to nerves. These we find summed up as follows by a writer in the 'Edinburgh Monthly Medical Journal' for January, 1869, at pp. 646, 647:—

"There is a careful and interesting description of glossy skin

* See 'Guy's Hospital Reports,' iii., 7: 1861.

† See 'Lancet,' July 10, 1869; and 'Holmes' System of Surgery,' i., article "Accidents from Lightning," p. 750.

following wounds of nerve-trunks. The appearance of the skin in this condition has been likened by Mr. Paget to that of chilblains. The integument becomes red and polished, in spots or patches. The hair is wanting. Sometimes the sensibility remains as usual; sometimes it is increased; sometimes diminished. The case cited as exceptional is curious enough. A man received a bullet wound, apparently implicating the axillary artery and musculo-spiral and median nerves. 'Very early in the case his first and second finger and thumb slowly enlarged without any premonitory signs, and with slight darting pains.' This continued after the wound had closed. Two months after the wound the skin of the affected part peeled off *en masse*. Seven months after the injury, when the case was last seen, sensation was wanting in the first, second, and half of the ring finger, and in the half of the thumb, though neuralgic pains were referred to these parts. The palm and first two fingers were enlarged. The skin was thickened, and of a dark purple colour. It is not surprising that the American surgeons should be struck by the resemblance between this and the disease called Elephantiasis Arabum. While in India, we have several times seen two or three fingers enlarged to twice the size of the others, and the skin pink and glossy, contrasting with the black skin of the rest of the hand.

"Other lesions of nutrition or secretion following wounds of nerves are also pointed out. Sometimes there were copious acid sweats; sometimes there was dryness or desquamation of the skin, vesicular eruptions, or incurving of the nails, or subacute inflammation of the joints, favouring the conclusion that the lesion of the nervous trunks acts upon the nutrition of the parts, independently of the loss of sensation or motor power."

The nutritional lesion at the peripheral distribution of the nerve, however, may, if it persist sufficiently long, become in its turn the causative condition of what was in the first instance but a result in common with itself of the lesion of the nerve-trunk. For Dr. Mitchell "claims the merit of having pointed out what was practically unknown before his own researches, namely, that loss of motor power, in a vast majority of cases, is finally due less to neural defects than to those obstinate consequences in the range of nutrition which result from the loss of nerve-power, and which may continue long after the motor power has been partially or completely restored."

Many similar cases may be found recorded by Mr. Jonathan Hutchinson in a very valuable paper, consisting of "Observations on the Results which follow the Section of Nerve-trunks, as observed in Surgical Practice," which was published in the 'London Hospital Reports' for 1866. Mr. Hutchinson is inclined to explain the phenomena of lessened temperature and those of lessened power of maintaining temperature which accompany these lesions, by the lessened

vis a fronte of the tissues surrounding the capillaries and acting then upon the circulation. The present writer is only half inclined to believe that this is a *vera causa* in animal hydraulics or "hæmaulics;" and that at all events we are not absolutely necessitated to accept it as such, though the absence of any other plausible hypothesis may be seen from the following record of an observation made and published by him before he was acquainted with either of the two memoirs just referred to. This record will be found in 'Medicine in Modern Times,' at p. 69, and to the following effect:—

"The following short history seems to me to be a good instance of the action, or rather of the want of action, of the peripheral nerve-system upon the arterioles. A man, who came some years ago under my own care had had a bullet pass through his arm just above the elbow, so as to sever the musculo-spiral nerve. The scars of exit and entrance were in the lower third of the arm. Under ordinary circumstances the soft parts of the lower arm maintained their natural consistence; but their power of resisting changes of temperature was greatly impaired, as well of course as the sensibility of the parts supplied by the injured nerve. I recollect seeing the swollen state of the inner side of the hand one cold, raw morning, when the man was on sentry duty, and had his hand chilled down by the musket he had to carry. Now, I apprehend that this turgescence is to be explained by saying that the local or peripheral nerve-system of the affected parts was competent under ordinary circumstances to regulate the calibre of the arteries; but that its activity was liable to be depressed, as under the circumstances related, into actual abeyance in the absence of any possibility of any assistance being supplied to it from the cerebro-spinal nerve-axis. Thus, under the depressing effect of cold, which seems to work here much as it does in checking the regeneration of artificially amputated parts in snails and in salamanders,* the peripherally-placed ganglionic system was put into abeyance, and turgescence of the vessels it ordinarily supplied witn 'tone' ensued."

It may be said that we do actually know and can see that a nerve when severed from its central connections undergoes fatty degeneration; that it is reasonable to suppose that its mal-nutrition may entail a consentaneous mal-nutrition in the parts which it supplies; and that this secondary mal-nutrition may account for the reduction thus witnessed of the tissues of warm-blooded animals to the level of those of the cold-blooded classes. But to this we reply that atrophy of the nerve-trunk is one thing, and a thing very demonstrable; whilst atrophy of the terminal nucleate plexus, in which so many nerves have of late been shown to terminate, is another thing, and as yet an undemonstrated one. Indeed the physiological existence

* 'Müller's Physiology,' by Baly, 2nd edition, i., p. 444; Bonnet, 'Œuvres,' tom. v., i., pp. 328, 329.

of these peripheral nervous apparatus has only just established itself as a fact in science,* and so far as the writer is aware, nothing has as yet been attempted as to their pathological history. And weighing hypothesis against hypothesis, the writer still thinks his own, which would explain the facts in question as referable to an impairment of power, to be, at least for the earlier stages of the history, as probable as the counter-hypothesis, which suggests a consentaneous though early alteration of nutrition, as an explanation of the phenomena.

It may be well to add that the changes in question, or at least some of them, have been observed in non-traumatic cases of nervous disease, such as shingles affecting the arm.†

The cases which we shall now, in the fourth place, proceed to relate appear to us to show distinctly that nerve-force can act on tissues, and that directly, without, that is to say, any intervention of the blood-vascular system. The first of these is a typically good instance recorded by a typically good observer. In the twentieth volume of the 'Medico-Chirurgical Transactions' (1837) we find the late Sir B. C. Brodie writing as follows:—"A man was admitted into St. George's Hospital in whom there was a forcible separation of the fifth and sixth cervical vertebræ, attended with an effusion of blood within the theca vertebralis, and laceration of the lower part of the cervical portion of the spinal cord. Respiration was performed by the diaphragm only—of course in a very imperfect manner. The patient died at the end of twenty-two hours; for some time previously to his death he breathed at long intervals, the pulse being weak and the countenance livid. At length there were not more than five or six respirations in a minute. Nevertheless, when the ball of a thermometer was placed between the scrotum and the thigh, the quicksilver rose to 111° of Fahrenheit's scale. Immediately after death the temperature was examined in the same manner and found to be still the same."

Now temperature often rises in the presence of great lividity, in the absence, that is, of any but a very imperfect degree of arterialization or oxidation, though not, of course, in the absence of chemical change. Dr. Gray, of this place, informs me, as I write, that in a case of pneumonia, recently under his care, the temperature rose as high as 106° F. But in the case just quoted from Sir B. C. Brodie's memoir no such over-active cell-formation as that which characterizes pneumonia, and indicates its presence by monopolizing the currency of chlorides, can be reasonably supposed to have been present; and we appear to be shut up to the accepting as an explanation the showering down from the irritated and isolated segments of the spinal

* See Stricker's 'Handbuch der Lehre von den Geweben,' ii., p. 189, 1869. Dr. Beale, 'Royal Society's Proceedings,' 1865, p. 249.

† See Paget, 'Medical Times and Gazette,' 1864, March 26, *cit.* Handfield Jones, 'St. George's Hospital Reports,' vol. iii., 1868, p. 99.

cord of such an amount of stimulus as was competent to throw the tissues of the lower parts of the body into active chemical change. That this explanation is a *vera causa* the following facts will show. Dr. Semper, in his magnificent work on the Philippine Archipelago,* has given us an account of certain Echinodermata, of the class Holothurioidea, the source of the article of commerce known as "trepang," from which we learn that several of these curious animals have the power of dissolving their integument into a kind of amorphous slime, upon irritation even of so gentle a kind as simple removal from the sea water. In the case of one species, *Stichopus naso*, it has been found necessary to kill them by heating the water without removing them from it, as otherwise their dense integument runs into dissolution, and the animal is spoilt for the Chinese market, in which, when well preserved, it commands a specially high price. If, now, fragments of the integument of one of these creatures be placed under the microscope, and whilst there, be irritated with the point of a needle, the process of self-dissolution is observed to be expedited in direct correspondence with the amount of stimulus applied. In this diffluent slimy mass beautiful reticular and nucleate nerve-plexuses are to be seen, surviving, which is not always the lot of destructives, the destruction they have brought about. Nothing can speak more clearly to the "catalytic" power of nervous organs, unless it be the rationale given by Mr. Paget, as reported in the British Medical Journal for January 22, 1870, of the formation of sloughs and bed-sores. There Mr. Paget is reported to have observed that "simple *loss* of nerve-power is followed only by *wasting* of the paralyzed parts; but if in addition to loss there is *disturbance* of nerve-force, we then find disturbances of nutrition quickly following the injury, such as extensive bed-sores and sloughing of integument on the feet." To this we should add that if the nerve-system does not play the part of King Stork, other irritants may; and that animal structures deprived of the eminently animal assistance which a connection with a central nervous system secures to them succumb to shocks to which, when thus reduced almost to the level of vegetable tissues, they ought not in fairness to have been exposed. The discordant results of observations as to the consequences of paralysis of many, and especially of the trifacial nerves, can be harmonized if these two considerations are kept before the mind.

For the literature of this subject and much else that is valuable relating to it, see *Handfield Jones, 'St. George's Hospital Reports,'* iii., 1868, p. 89; *Funke, 'Lehrbuch der Physiologie,'* Bd. ii., 62 to 775; 1866: *Herman, 'Grundriss der Physiologie,'* pp. 79, 293, 298; 1867: *Dr. Anstie, in 'The Practitioner,' March,* 1870, p. 166.

* 'Reisen im Archipel der Philippinen,' iii., 72; iv., 158, 171; v., 200. 1868.

V. RECENT OBSERVATIONS ON UNDERGROUND TEMPERATURE, OR THE CAUSES OF VARIATION IN DIFFERENT LOCALITIES. By Edward Hull, M.A., F.R.S., Director of the Geological Survey of Ireland.

Within the last year several series of experiments on the rate of increase of underground temperature of more than ordinary interest have been carried out, on which I propose to offer a few observations. On a former occasion I ventured to give a summary of the experiments which had at that time been carried out on this interesting branch of inquiry, and to point out a course which, in my opinion, would if adopted enable us to ascertain the rate of increase at depths hitherto unexplored.* It is satisfactory to find that the plan proposed has met with the approval of the Committee appointed by the British Association for the Advancement of Science, for the purpose of "investigating the rate of increase of underground temperature downwards in various localities." The report for the past year, drawn up by Professor Everett at the request of his colleagues, has now been issued, and contains an account of experiments undertaken by Sir William Thomson, F.R.S., and his assistant, Mr. McFarlane, in the vicinity of Glasgow, and by Mr. G. J. Symons at Kentish Town in the metropolis, at the deep boring of the New River Company. These observations were taken in water which filled the bore-holes, each layer or stratum of water being assumed to correspond in temperature with that of the surrounding stratum of rock; and the instruments used were those invented by Sir W. Thomson and Professor Phillips respectively for avoiding a source of error (though one not of much importance) arising from the pressure of the water at considerable depths on the bulb of the thermometer.

Of the two experiments made near Glasgow: one, taken at Blythswood reached a depth of 525 feet, with an ultimate temperature of 59·52°;† and the other, taken at South Balgray, reached a depth of 347 feet, with a temperature of 53·69°. At a depth of about 60 feet the constant temperature was reached, and the result obtained at the Blythswood bore was 1° for every 50·5 feet, and at the South Balgray bore 1° for every 41 feet, a rate of increase much in excess of the former; and, I may add, of the mean results of other experiments.‡

* 'Quart. Journal of Science,' vol. v. 1868.

† All measurements of temperature in this paper are given in degrees of Fahrenheit.

‡ The rapid increase in this case appears to have arisen from the large proportion of shale at the depth between 390 and 450 feet. Mr. W. Hopkins has shown that the increase of temperature is in the inverse ratio of the thermal conductivity. 'Phil. Trans.,' vol. cxlvii.

A question of speculative interest was determined in a bore made at Kirkland Neuk. A coal-seam passed through had been charred, owing to contact with greenstone (or trap rock); and the question occurred, "Are there any remains of the heat which charred the coal in ancient times; or has it passed off so long ago that the strata are now not sensibly warmer on account of it?" The observations seemed to establish the latter alternative, the bore being colder than its neighbour—that taken at Blythswood.

The observations taken at Kentish Town extended to a depth of 1100 feet, with an ultimate temperature of 70°, giving the mean rate of increase at ·0191° per foot, or 1° per 52·4 feet, the mean surface temperature being taken at 49°.

In the case of the Kentish Town bore-hole, notwithstanding the care taken to prevent the influence of the external air affecting the temperature of the water in the well, it was found by Mr. Symons that this influence extended to a depth of nearly 200 feet,—the temperature of the water rising and falling with that of the season of the year down to this depth. The well, however, was no less than 8 feet in diameter.

The experiments undertaken at Rose Bridge Colliery, near Wigan, by the manager, Mr. Bryham, which I have recently communicated to the Royal Society,* deserve special notice, as having been made during the sinking of the deepest coal-pit in Britain. The results arrived at differ so strikingly from those obtained at Dukinfield Colliery, situated near the eastern border of the same coal-field of Lancashire, and only a little less deep, that a discussion of the cause of this discrepancy may not be without interest.

An account of the observations at Dukinfield Colliery, undertaken by Mr. W. Fairbairn, F.R.S. (1848–59), has already been given in the pages of this Journal,† and was originally communicated by Mr. W. Hopkins to the Royal Society.‡ The depth of the shaft is 2151 feet, with an ultimate temperature of 75·5° taken in the seam of coal known as the "Black Mine" of that district. The mean result is a rate of increase of 1° for about every 83·9 feet.

The observations at Rose Bridge, near Wigan (1854–61), were at first extended only to the depth of 1800 feet, giving a resulting temperature in the strata of 80°; but it having been determined by the proprietor to carry down the shafts to the "Arley Mine" coal, which was known to be at a depth of over 600 feet below, operations were commenced in the spring of the year 1868, and in the space of fourteen months the Arley Mine was successfully "won." The total depth reached was 2424 feet, with an ultimate temperature (taken in the coal itself) of 93·5°. Throughout the whole series of experiments from 1650 feet downwards, the increase

* 'Proceedings of the Royal Society,' vol. xviii. (No. 116), p. 173.
† Vol. v., p. 17. ‡ 'Philosophical Transactions,' vol. cxlvii.

appears to have been tolerably uniform, giving the impression that there were no disturbing causes at work. The resulting proportionate increase was found to be 1° for every 54·57 feet; the "invariable stratum" being assumed at 50° of temperature, and at a depth of 50 feet from the surface. The results of the observations at Rose Bridge as compared with those at Dukinfield show a remarkable dissimilarity. The rate of increase in the former case being much more rapid than in the latter: for assuming the same standard of departure in both cases, it will be found that in the case of Rose Bridge the rate of increase is 1° for about 47·2 feet as against 1° for about 83·2 feet at Dukinfield; an amount of discordance which I am satisfied is to be explained on other grounds than those of error in the observations themselves.

Such a diversity of results cannot be attributed to differences in the conducting powers of the rocks in each locality: for although sections of moderate depth taken at two different parts of the same coal-field would undoubtedly present different proportions of the sandstones, clays, and shales, &c., arranged in a varying manner to one another, which combine to form what is termed the "Coal-measures;" yet if observations in each case be extended downwards to considerable depths, such as those in the present instance which exceed 2000 feet, the varieties of strata will tend to balance each other, and all cause of discrepancy in the rate of increase of temperature will probably disappear, or be reduced to such a degree as to be immaterial.

Neither is this diversity to be attributed to the presence or flow of water in the strata; for, as I observed on a former occasion,* the percolation of water decreases with the depth, and at variable distances from the surface altogether ceases; or is limited to the very small quantity which appears in some cases to have been locked up in the strata for ages, and which of course takes the temperature of the surrounding strata themselves. We must, therefore, seek for other causes to explain the dissimilarity of results in question.

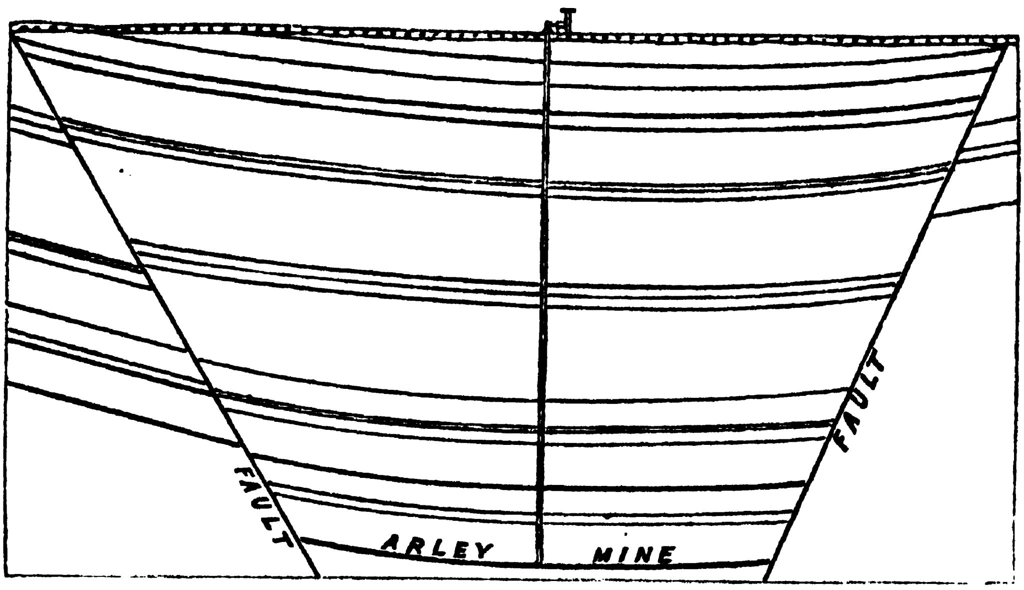
The amount of inclination in the strata, is a cause of variation in the rate of increase which has not as yet been sufficiently taken into account, but is one which I think ought not to be lost sight of, especially in comparing results obtained at moderate depths. In the case of strata of uniform composition throughout, as the Chalk, or New Red Sandstone formations, the amount of inclination is of comparatively little importance; but where we have to deal with a formation such as the Coal-measures, composed of variable strata alternating with each other, and possessing varying degrees of thermal conductivity, the inclination, or amount of dip of the beds, becomes an element of much importance when the rate of increase

* "Experiments for Ascertaining the Temperature of the Earth's Crust." 'Quart. Journal of Science,' vol. v., p. 18.

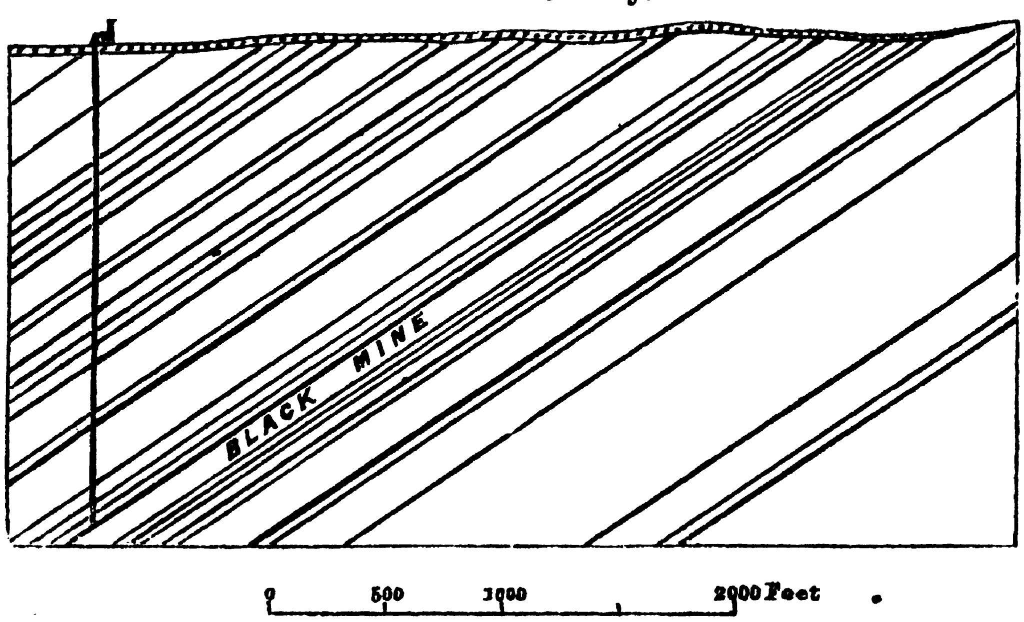
of temperature is under discussion. In my communication to the Royal Society I have ventured to suggest that the discordant results obtained at Rose Bridge and Dukinfield are to be attributed to the difference in the inclination of the strata at the two collieries, and I propose to enter a little more fully into the discussion of the question here. I shall now describe in detail the position of the strata in each locality.

Sections showing relative positions of the strata at Rose Bridge and Dukinfield Collieries.

Rose Bridge Colliery.



Dukinfield Colliery.



Scale of Feet.

Rose Bridge Colliery.—That part of the South Lancashire Coal-field known as "the Wigan Coal district," is traversed by a series of parallel faults, ranging in a north-westerly direction, with occasionally very large displacements of the strata. These faults divide the coal-field into sections or "belts;" and where the strata are let down between two faults, a "deep belt" is produced; on the other hand, where the strata are thrust up, "a shallow belt" is the result. The

same coal-seam being thereby placed at a less depth from the surface than in the case of the "deep belt."

Between these faults the strata incline at small angles, generally dipping gently to the eastward.

Nearly in the centre of one of these "deep belts," Rose Bridge Colliery is situated; the belt being bounded on the west by the "Standish fault," along which the strata are let down on the eastern side about 150 yards; and on the east, by the Kirkless Hall fault, along which the strata are let down on the west about 600 yards. At the colliery itself the strata are almost horizontal; consequently all the strata, except those comparatively shallow, are broken off by the large faults above described before they reach the surface.

Dukinfield Colliery.—The circumstances of the strata at this colliery are very different from those of Rose Bridge. The pits are situated on the Cheshire side of the river Tame, near Ashton-under-Lyne, and in this district the beds rise and crop out to the eastward at high angles. At the colliery, the dip is west at about 35°, and the "Black Mine" (or coal), which was reached at a depth of 2151 feet, crops out at a distance to the eastward of little more than 1000 yards.

From this account it will be seen that we have very different stratigraphical conditions in each locality, and to this I attribute in a great measure the difference in the rate of increase of underground temperature in these localities respectively. For purposes of comparison we may assume a constant supply of heat from the interior of the earth, tending to travel towards the surface. In its progress it meets with strata of different conducting powers, the thermal conductivity of each stratum in the same locality being in the inverse ratio of the rate of increase, as shown by Mr. W. Hopkins, F.R.S.,* in other words, where the rate of increase is rapid the conducting power is small.

But whatever may be the conducting power of a series of strata, it seems probable that it is impeded when the heat has to travel in a direction perpendicular to the planes of bedding. On the other hand if the heat can find its way towards the surface partly along the planes of bedding, the thermal conductivity is increased, and the rate of increase is proportionally lessened; for in this way it may be conveyed by strata which have high conducting powers, and escape along the outcrop of the strata themselves.

If this view be correct, we can at once account for the difference in the results at Rose Bridge and Dukinfield collieries. In the former, owing to the horizontality of the strata, the heat can only find its way outwards directly across the planes of bedding. We may, therefore, suppose that the resistance to its motion is increased thereby; the conductivity is lessened, and, in consequence, the rate

* 'Philosophical Transactions,' vol. cxlvii.

of increase of temperature is rapid. In the case of Dukinfield it is inferred that, owing to the high inclination of the strata, some of the heat travels along the planes of bedding, and escapes along the outcrop with greater rapidity than it would if it were obliged to travel solely across the strata themselves.

It has been suggested that in the case of Dukinfield Colliery the escape of the underground heat may have been facilitated by the formation of vapour at certain depths, the vapour making its escape along the planes of bedding by the aid of the fissures and porosity of some of the rocks. It is questionable, however, whether the elastic force of the vapour would be sufficient, at the comparatively low temperature of the strata, to overcome the enormous pressure to which it would be subjected at depths much below the surface.

VI. MR. BRUCE'S MINES REGULATION BILL.

MODERN legislation in this country in reference to industrial employments tends more and more to impose on the Government the duty of caring for the health and safety, and at least the elementary education, of those who, owing either to weakness or to ignorance, are unable to care for themselves.

In our Factory Enactments, foreign countries have followed gradually in our footsteps; in the regulations affecting the mining population, on the other hand, we shall probably never attain the completeness of supervision, be it for good or for evil, which prevails in States such as France, Belgium, and Prussia, where the minerals are the property of the nation.

Mr. Bruce's Bill for the Regulation and Inspection of Mines, a *réchauffé* of his Bill of last Session, consolidates the existing laws; but is in other respects as modest a measure as the opponents of Government interference could desire.

It continues to forbid females to work in mines, and, at the urgent request of the operatives, limits, though not to the full extent of their desires, the time during which youths from twelve to sixteen years of age may be employed below ground. Recognizing the failure, in the case of young children working in mines, of the attempt made to combine work and elementary instruction, it forbids entirely their employment underground before the age of *twelve*. It places women, young persons, and children employed on the surface under the provisions, as regards the hours of labour and education, of 'The Workshops Regulation Act of 1867,' which, however, owing to its administration being in the hands of local

bodies, is a dead letter. Otherwise than under this Act, it makes no provision whatever for the education of the mining population.

Should Mr. Forster's Education Bill become law in its present form, which leaves each district to judge whether parents shall or shall not be compelled to send their children to school, then the children in the mining districts of the North and of Cornwall will probably learn the elements of reading, writing, and arithmetic. We wish we could expect as much with regard to Staffordshire. The Revised Code must, however, be re-revised before even the former will, as a matter of course, have the opportunity of learning something of the laws of nature on which their safety depends.

As to the persons responsible for the conduct of such hazardous works, to require of them the rudiments not of a scientific but of the most ordinary literary instruction would, according to Mr. Bruce (perhaps rightly for some few years to come, and in certain localities), disqualify unfairly, and without benefit to the community, men who may be competent, though illiterate. We hope that the example set by those West countrymen, who, in addition to their hard day's labour underground, attend the science classes of the Miners' Association of Cornwall and Devon with assiduity and success may, after a time, be followed elsewhere.'

The duty of "producing an amount of ventilation in collieries, adequate to dilute and render harmless noxious gases to such an extent that the working-places and roads shall be in a fit state for working and passing," is enforced more peremptorily under the bill than according to the existing law, inasmuch as the proof of its fulfilment is, in the event of an accident, to rest with the owner, instead of being taken for granted unless disproved. Strangely enough both the masters and the miners object to this condition as too stringent. Another provision which renders owners and agents, like the men, liable to imprisonment for breach of rules is more likely to pass, although the objection has been raised that it might lead to the incarceration of the Secretary for the Colonies. Why he should not be imprisoned, if he were to entrust the management of his mines to incompetent managers, does not appear very clearly. We suspect that the locking up of Monsieur Flachat, the Chief Engineer of the Chemin de l'Ouest, after a great railway accident in France, has contributed in no slight degree to the safety of railway passengers in that country.

No change is to be made in the system of colliery inspection, for two reasons: It is supposed, first, that to inspect every mine carefully and at short intervals would require 200 competent officials. This is an evident exaggeration, and one which it is scarcely to be expected that the present body of inspectors will take much trouble to dissipate. At any rate, when it appears that the number of mines of South Staffordshire and Worcestershire

(Mr. Baker's district) is returned at 550, and on comparing it with the returns of the Keeper of Mining Records, we find that more than *two hundred* of that number have ceased working (many of them for six or seven years and longer), this aspect of the question would appear to require further investigation.

The second objection, if valid, would be more formidable. It is argued that the responsibility of the actual managers of collieries would be diminished if a more close and systematic supervision by government inspectors were attempted. Doubtless it would be a mistake to exonerate an incompetent manager on the certificate of an equally incompetent government official. This is not what is wanted, but that the inspectors should have such a knowledge of the condition, as to discipline and safety, of every mine in their district as a personal inspection can alone afford. Where this is honestly attempted, as in Mr. Brough's (the South-western) district (and we mention Mr. Brough's case as an example and not as a solitary instance), the solicitation and advice of a man of large experience and of sound acquirements would tend to bring the practice of inferior managers up to the best standard of their own and other localities.

We are not so sanguine as to suppose that any degree or quality of inspection will prevent a recurrence of lamentable catastrophes. With the increase in depth of our coal mines the frequency of the sudden and dangerous outbursts of gas necessarily increases; against them no management of details is of much avail without the faculty of increasing the supply of air almost indefinitely, now happily afforded by the exhausting fans of Lemielle, Guibal, and others, which are rapidly coming into use in the North of England and in South Wales. Another source of constant danger is the recklessness of the mining population, which will only be removed by such a change in their habits as time and education can alone produce.

But with all this a more vigilant supervision by the representatives of the central authority cannot fail to increase the good order and safety of collieries as it has done that of factories. It appears to us that the country cannot rest satisfied with the present pseudo-inspection, or rather post-mortem revision, serving, as it does in nearly every instance, to show merely that the inspector had no knowledge whatever of the condition in any respects of the pit in which the fatal accident arose.

VII. ON PRACTICAL SCIENTIFIC INSTRUCTION.

By George Gore, F.R.S.

The remarks in the following paper are directed more particularly to education in physical and chemical science, not because there are no other sciences to which they would apply, but because those are the sciences selected as illustrations of scientific education.

It is generally considered that of late years a more rapid progress has been made in trades and manufactures in America and in some of the countries of Europe, more particularly in Prussia, than in this country, and that this is chiefly due, not only to the existence of compulsory elementary education in some of those countries, but also largely to the more general diffusion of scientific knowledge amongst foreign workmen and directors of workmen. So far has this opinion spread amongst those who are best informed upon the subject, especially since the Paris Exhibition of 1867, that it is thought unless great efforts are made in this country to ensure a general and wide-spread knowledge of science, the prosperity of our manufactures must speedily decline.

To avert such a calamity "technical education" has been proposed, and much has been said as to the means of supplying it. "Technical education," in the fuller sense of the words, consists of two things, *viz.* education in a school and instruction in a manufactory; but in the narrower sense it means the practical knowledge and experience acquired during apprenticeship in a workshop.

The object of "technical education" is essentially practical—it is to make each pupil, whether intending to be a master or a workman, better able to fulfil the duties of the special occupation in which he is to be engaged; for instance, to make a worker in brass a better brass-worker; an iron-smelter a more skilful smelter; an electroplater a better plater; a farmer a better farmer, &c.; and the means proposed for doing this is by a suitable course of scientific and technical culture at an early age. Ordinary school education is supposed by some persons to be only intended to impart such a general discipline of the mind as will fit a man for every employment, without fitting him specially for anything. Technical education, on the other hand, is more for the purpose of fitting a man for a special pursuit.

Some persons say technical skill is a quality which cannot be imparted,—it is a gift of Nature. There is no man so great a genius that education will not improve him; skill in art does not come wholly of itself, any more than knowledge of science does. Under the present system multitudes of workmen of ordinary capacity in this country fail to learn because they have no proper teach-

ing; we must not, therefore, trust to genius only, and the "rule of thumb," as we have hitherto done, but judiciously impart scientific instruction to minds of ordinary capacity as well as to others.

The education necessary for a workman cannot be completely supplied either in a school alone or in a workshop alone. The duties and pursuits of a school are incompatible with those of a manufactory, and it is not possible that a workshop should also be a school of science. In an ordinary school, boys should be taught the general scientific facts and principles upon which trades and manufactures are based; and in the manufactory they should learn the practical directions for working in their trades, and acquire experience in manipulation.

It is manifest that no scientific education, whether technical or otherwise, can be imparted except upon the basis of a sufficiently good elementary secular education; and as long as the elementary education in this country remains in its present extremely imperfect state, it is impossible for this nation adequately to advance in scientific knowledge, or keep pace with the progress of foreign intellect.

It may be asked,—At what point is the school education to stop and the workshop education to begin? This admits of a sufficient although not a precise answer: in a general way school education would cease where manufacturing manipulations commence, but this would vary with the kind of school. The relations of science to trade would be carried to a farther stage of development in a "trade school" than in a school of a different kind; and in courses of lessons or lectures on technology, than in ordinary scientific instruction; they would also usually receive further development in schools in a manufacturing district than in those of other places. In a usual way the technical portion of ordinary school education would include illustrations of the principles and facts of science by descriptions of manufacturing processes, by models and diagrams of apparatus used in manufactures, and by specimens of manufactured products in their different stages of development. It would also, in some schools, include a limited amount of practice in chemical analysis, but would not include actual manipulations by the pupils in manufacturing arts. In "trade schools" technical education might be carried to a greater extent: the pupils would be taught some of the practical working directions of various trades, the handling of ordinary tools, and the modes of manipulation of various substances, and thus such schools would form an intermediate stage between ordinary schools and the workshop. Experience in the production of manufactured articles for sale will probably always be obtained in a manufactory alone.

As I shall have occasion to use the words "science" and "art," I will first state what I mean by them:—A science consists of laws,

principles, and facts; an art consists of technical directions and manipulations; and the latter is in all cases based upon the former, although in some instances the connection between them may not be well understood. Thus we have the science of electricity, and the arts of electric telegraphy and of electro-plating based upon it; and the sciences of heat and chemistry, with the arts of ventilation, photography, soap-making, iron-smelting, &c., depending upon them. In science, the great aim is truth and accuracy; in art and manufacture the chief object is to produce the best practical result at the lowest possible cost.

Every special art or manufacture consists essentially of some particular process, or series of operations, generally reduced to the greatest degree of simplicity in order to lessen the cost of production. In each different trade or manufacture a knowledge of the process is implicitly embodied in a number of instructions and details with which each workman is supposed to be fully and familiarly acquainted. Each manufacture is an art, the methods of which are based upon definite scientific facts and principles. What an English manufacturer generally expects of a workman is not a knowledge of the science or sciences upon which his manufacture is based, but a knowledge of those empirical methods, and ready practical experience in their use. In accordance with this expectation an English workman usually possesses a knowledge of the empirical methods or directions of his trade, but rarely understands their scientific basis: for example, a brass dipper knows that the methods for cleaning a figured piece of brass is to dip it into aqua-fortis, but does not understand the general chemical relations of acids and metals, or the special chemical effects of aqua-fortis on brass. The empirical methods of his trade, without which a workman could not work at all, have of necessity always been taught him, but a knowledge of their scientific basis, which would enable him to work to the greatest advantage, has been greatly neglected.

In some cases this blind following of methods, sometimes called "the rule of thumb," is sufficient, though very imperfectly so, for the manufacturer's purpose, which is to make the production of his goods as much as possible a *matter of routine;* but in most trades the following of empirical rules alone very frequently does *not* lead to the desired perfect result, the articles produced are imperfect, and then it is that a knowledge of science is necessary to enable the manufacturer or his men to avert or correct the evil. In such cases under present arrangements the manufacturer frequently finds fault with the materials supplied to him, or he sometimes applies to a scientific man for advice. In many cases, also, the following of those rules does not lead in the *best way* to the desired result, the materials, time, or labour are not used in the most advantageous manner, and the cost of the finished article is thereby made too great.

The selection of materials for manufactures by the "rule of thumb" alone leads to equally imperfect results. Nearly every manufacturer is aware by painful experience of the great and almost incessant variation that occurs in the quality and properties of the materials used in his trade, and the consequent frequent risk of failure of his process. In the manufacture of iron, for example, the presence of much phosphorus, sulphur, or silicon in the ore is very detrimental to the quality of the iron produced from it; in the manufacture of glass, the least quantity of iron in the materials will seriously injure the colour of the product; in the selection of copper for telegraph wire, if it contains the least trace of arsenic, the wire will not conduct the electricity properly. The difficulties experienced in getting suitable materials for a manufacturing process are in some cases very great; and when they are procured, additional difficulties arise from the inability of the manufacturer or his manager to analyze them.

Every manufacturer is also aware that the difficulties encountered in manufactures are not limited to the substances employed, but extend to all the different processes and stages of processes through which these substances have to pass, and to all the forces, tools, machinery, and appliances employed in those processes; in the manufacture of glass, for example, the greatest care has to be exercised in the making and gradual heating of the pots in which the glass is melted, the proportions of the materials, the construction of the furnaces, the management of the heat, and a whole host of minor conditions too numerous to mention, all of which must be attended to with the greatest care. In the manufacture of iron and steel, the smelting of copper, the refining of nickel, the preparation and baking of porcelain, and in many other trades, innumerable difficulties, all having their origin in the properties of matter and forces, continually beset the manufacturer. In some cases difficulties occur which perplex both the workman and the scientific man called in to his aid, and so far from an unscientific workman being able to overcome them, even with the aid of the scientific man, he is unable to do so.

The phenomena and changes which take place in matter and forces in nearly every manufacture are far more complex than men in general have any conception of; for instance, simply in heating a bar of iron to redness, a whole series of changes occur in its structure, its magnetism, its dimensions, its cohesive power, its specific heat, and its electric conducting-power, in addition to its absorbent power ("occlusion") of gases from the fire, and its superficial oxidation; the internal changes which occur in even so simple a phenomenon as this are so numerous, as to produce the impression that the substance is endowed with vitality. All these phenomena are doubtless only a very few of the number which really

occur in this substance. Faraday said of physical and chemical phenomena, "the little that is known is a great and wonderful indication of that which is to be known."

The hidden difficulties which beset a manufacturer are not unfrequently so inscrutable that the present state of knowledge in science fails to explain them. Who can tell why it is that wire-work of brass or german-silver becomes gradually brittle by lapse of time? or why varnish made in the open country has different properties from that made in a town? or why silk dyed in Lyons should possess a finer colour than the same silk dyed by the same process in Coventry? With our present extremely imperfect knowledge of Physical and Chemical science, we can perhaps hardly form an idea of the infinitely complex nature of the phenomena which it presents.

One of the inevitable results of all these difficulties in manufacturing processes and of unscientific management, is the production of a large amount of goods of an inferior quality; and useless goods, technically called "wasters," the cost of which has to be laid upon the saleable ones, and thus the price of the latter is enhanced to the consumer. For instance, flint glass discoloured by iron has sometimes to be sold at a loss for making common enamel; waste window-glass has to be sold as "rockery" for ornamenting gardens, and defective articles of glass or metal have to be re-melted.

Many of these difficulties arise from the inaccuracy and carelessness of the workmen, and would be lessened by the more general diffusion of scientific knowledge. If workmen and managers had more preparatory scientific training, and all apprentices were suitably educated in science, not only would the foregoing sources of loss and expense be lessened, but workmen would acquire greater habits of caution, and such accidents as arise from the want of these in the management of steam-boilers, explosive substances, and mines, would occur less frequently. A miner never having seen an explosion of coal-gas and air in a scientific lecture, does not adequately believe or realize the dangerous nature of the mixture; and workmen in general in this country do not sufficiently believe in the fearful properties stored up in substances, and in the forces of nature, because they have not seen them demonstrated by experiments. It is a curse of the ignorant to be incautious in actual danger, and to suffer terror where no real harm can occur.

Many of our working-men are fearfully reckless in circumstances where a small amount of scientific knowledge obtainable by witnessing a few experiments would show them the existence of extreme danger. We read accounts of barrels of gunpowder being kept in blacksmiths' shops; of cans of damp gunpowder being set on a hob to dry; of nitro-glycerine being conveyed in a jolting cart, and of its being used to grease the axles of wheels; of a lighted

candle being taken to a burst cask of petroleum, or into places known to be full of escaped coal-gas; of miners habitually carrying keys to open their lamps in the explosive atmosphere of coal-mines; and of men smoking pipes in barges laden with gunpowder. Frequent mishaps or accidents in the management of material substances are a sign of minds untrained in science.

Our working-men are also frequently very wasteful in the use of substances and forces; not having the skill to use them economically, they try to obtain increased quantity of results by a too liberal employment of means. In consequence of the greatness of our supply of coal, and a want of knowledge of science, British manufacturers have also been exceedingly wasteful of the force of heat. Coal differs from nearly all other abundant substances by containing within itself an immense store of power. Every particle of coal we use contains sufficient power stored up in it to lift itself a height of more than two thousand miles, or a pound of it contains enough power to lift a ton nearly a mile high.

There is no manufacture which does not continually involve a necessity for scientific knowledge. Every person who has to operate either physically or chemically upon material substances, or who has to superintend such operations, ought certainly to possess a general knowledge of the forces and materials under his care. A man who handles a substance should be familiarly acquainted with all its leading properties. Rational knowledge is far more valuable than empirical knowledge. A man who understands a principle can solve a new difficulty nearly as well as he can an old one. In the management and manipulation of materials it is manifest that a workman who possesses an intelligent knowledge of the principles of the processes, and of the properties of the forces and substances with which he is dealing, in addition to the every-day working experience, is better able to prevent accidents, correct errors, and vary the process so as to produce special effects; and must also, in many trades, be a better artisan than he who has only the daily working experience, guided by the "rule of thumb." In all manufacturing employments, science, combined with natural ability, is the only true foundation of skill. There is no kind of physical labour, however simple and rude it may be, in which superior intelligence does not enable a man to produce better or larger results. In most other human affairs the means employed are adapted to the object in view, but in the manipulations with natural forces and material substances in this country, men are nearly always employed who are largely ignorant both of the one and the other. Faraday, in his evidence before the Government Commission appointed to inquire into the state of science education in our large public schools, stated that "we cannot find the intelligent common man in this country."

What is really wanted in our workmen and managers is not the

substitution, even in the slightest degree, of scientific knowledge for the knowledge of the special methods of their trades, nor even that they should be largely acquainted with some one branch of science, but that they should be much *more largely acquainted than they are with the leading facts and principles of the sciences upon which their own special arts and manufactures depend, and* that they should know *how such knowledge is applied and how these principles operate in their several occupations.*

With workmen and managers more scientifically skilled, all our machinery and processes would produce better and greater results, and labour and materials would be greatly economized. Instead of employing the present wasteful system, of making several unscientific attempts to produce an article, before succeeding, workmen would arrange their plans in a scientific and systematic manner beforehand, and thus be able to succeed in an undertaking at the first attempt. If workmen were more skilled, they might be entrusted with the care and direction of improved machines, by means of which labour and materials might be still further economized, and production increased to an enormous extent. That immense improvements remain yet to be made in our manufactures is shown by the fact that, even in the steam-engine, which is supposed by most persons to be so perfect, we only obtain less than one-tenth of the mechanical power producible by the heat contained in the coals, the remainder being lost in a variety of ways, largely within the machine itself.

Not only are workmen and managers in this country insufficiently acquainted with science, but their employers are as a rule nearly equally so, and simply because in the great majority of cases they have been educated in schools where science was not taught. Several manufacturers and large employers of labour have regretted to me the fact, that science was not taught them when they were at school. The general ignorance of science by our manufacturers is also shown by the absurdity of a large proportion of our patents. An advance in such knowledge must in most cases begin with the employers rather than with the employed, for it would be reversing the natural order and fitness of things for the workman to be better acquainted than his master with the employment: knowledge in general should descend from above.

A greater amount of knowledge of the general principles of science is desirable both in masters and men, and particularly of those sciences which relate to their trades. It is desirable in the workman, because he is most immediately in contact with the process, and could therefore more quickly detect a fault and prevent or remedy an accident, and also because he would be otherwise incompetent to understand and carry out the instructions of his master. It is a well-known and frequent complaint with some em-

ployers of labour that they cannot induce their workmen to vary or alter their process, even in cases where it is absolutely necessary; the workman in his ignorance opposing every improvement. A scientific workman is more likely than his master to suggest improvements in a manufacture, because he feels the wants or defects of the process, through being in immediate contact with it. A knowledge of science is also desirable in a master, in order that he may be able to intelligently direct his workmen in their difficulties. Under present circumstances, it not unfrequently happens that improvements suggested by workmen are ignored and discouraged by masters, in consequence of the latter being ignorant of science; and in this way numerous instances of dissatisfaction have arisen between master and man, and important inventions have probably been lost to the nation through want of proper trial. It was chiefly by the genius and ability of working-men that steam-engines, the cotton manufacture, and the whole system of modern machinery was developed, by means of which this nation has obtained such immense wealth.

It has been objected to me by some manufacturers, that "scientific workmen are conceited, unmanageable, and continually wanting to make alterations;" and there is a large amount of truth in these remarks. If scientific education was more generally diffused amongst workmen, a greater degree of equality of intelligence would exist, and the cause of conceit be removed. In many instances, where such workmen have been found to be interfering and desirous of making alterations, the annoyance has arisen not solely from the conceit of the working-man, but in part also from the ignorance of science by his employer.

It has also been remarked to me that "a little knowledge in a workman is a dangerous thing;" it might be much more truly said that still less knowledge is a still more dangerous thing. Knowledge we know imparts power, and power requires to be regulated; knowledge in a workman requires to be regulated by greater knowledge in his master; and if the kind of scientific instruction afforded to workmen whilst boys at school, be specially directed to an inculcation of the principles and leading facts of physical and chemical science, there will be but little risk of its being superficial.

It has further been objected to me by a manufacturer that "science is making workmen more mechanical, and is driving all skilled labour out of the field." Although there is some truth in this, it is not a correct view of the case, the large introduction of science into trade within the last century, in the shape of telegraphs, steam-engines, gas manufacture, electro-plating, the manufacture of machinery, &c., has created a much larger demand for intellectually-skilled labour than ever existed before; and so large is this demand that a great difficulty experienced by nearly

all those who have introduced such inventions has been to obtain workmen possessing sufficient intelligence to manage their processes. It is also a well-known fact, and frequent complaint with manufacturers, that highly-skilled workmen are much too few in this country. The tendency of scientific improvements is to diminish the *physical* labour of the workman, but they require in its stead a greater degree of *intellectual* skill; they have mitigated his physical toil, by giving him the duty of intelligently directing the labour, instead of actually performing it. Workmen are now obliged to exercise the faculties of observation and judgment, in watching the results, and directing the action, of mechanical, physical, and chemical forces, instead of being themselves the physical machines, mechanically performing the work before them. A workman who is occupied all the day in laborious *physical* exertion, however great the skill required in that labour may be, arrives at his home at night in a condition fit only for sleep; whilst the man who directs a machine for performing the same labour is able after his toil to improve his mind by reading. Science has also increased the moral responsibility of workmen, by entrusting them with the management of all kinds of complicated and valuable machinery, requiring great care and exactitude of attention, upon the proper action of which the employment of many hundreds of workmen, and even the lives of numerous persons, not unfrequently depends; for instance, in the management of steam-boilers and engines. The lives of the whole of the passengers in a railway train also depend upon the skill and care of the engine-driver and fireman.

And it has been further objected to me by a manufacturer, that "science does not pay," or that "it does not pay anyone except a thoroughly scientific man; it does not, for example, pay a manufacturer or man of business." No doubt science, like everything else, benefits or pays only in its own special ways. With regard to this objection, we must distinguish between abstract scientific investigations made purely for the discovery of truth, without the slightest reference to personal profit, and investigations made for manufacturing or personal purposes; the former benefit the nation, but do not pay the investigator; the latter frequently benefits the manufacturer or person for whom they are made.

Scientific investigations made in a manufactory for the purpose of ascertaining the various sources of loss of materials, the circumstances which affect the amount or quality of the product; or made with the object of substituting cheaper or more suitable materials, or for varying their proportions, or for many other kindred objects, have in many cases resulted in great benefit to the manufacturer, and have formed in many instances the basis of successful patents. In confirmation of these remarks it may be stated that some of the large brewers, chemical manufacturers, candle companies, and many others,

constantly employ scientific men to examine their materials, processes, and products, and keep them acquainted with the progress of discovery and invention in relation to their own particular trades.

The benefit derived by a manufacturer from a personal knowledge of science is largely of an indirect kind, and cannot therefore be measured in direct money value, like the profit acquired upon a given sale of manufactured articles. This knowledge improves his judgment in nearly all questions relating to material substances and manufacturing processes. Numerous instances might be collected where even a small amount of knowledge of science in a master, has in this way been of great value in the prevention of accidents in his manufacture or trade. It benefits the manufacturer also by improving his observing faculties, enabling him more readily to detect imperfections in the quality of raw materials supplied to him, to discern faults in the processes, and different stages of processes, through which his materials have to pass, and to detect imperfections in the action of the various forces, tools, machinery, and appliances employed in his manufacture. It gives him the ability of intelligently directing his workmen in their manipulations, instead of being the subject of their ridicule in consequence of his ignorance of such matters. It enables him to form a correct estimate of the feasibility and value of suggestions of improvements in his trade, made to him by his workmen or others, and prevents his being led by enthusiasts and designing persons to spend his money and time upon hopeless inventions. A want of knowledge of science, on the other hand, has ruined many manufacturers, who have been induced to embark their money in demonstrably fallacious schemes which could not possibly succeed; in proof of this we need only examine the lists of patents, and we there find numerous absurd projects which have been promoted by men of business.

Many persons ignorant of science expect too much from a knowledge of it; and from the remarks made to me by some manufacturers, they seem to think that a little knowledge of science would almost at once enable them to make improvements in their trades. Without such knowledge, undoubtedly, our trades and manufactures could not have attained their present degree of excellence, and by means of such knowledge improvements are also continually being made; but important improvements in trades, like other valuable things, are not so easily obtained; for every single successful improvement actually effected, many unsuccessful and sometimes costly experiments have been tried, which are partly lost sight of by some persons, and the successful results alone are noticed. Numerous instances might be adduced of large sums of money having been lost in scientific experiments made with the hope of improving various arts and manufactures; for instance, in the numerous unsuccessful attempts to properly lay submarine telegraph cables. The losses

however, which occur in experiments scientifically made in this country, to improve manufactures, are extremely small, compared with those which result from unscientific attempts made with similar objects.

There may, perhaps, be some kinds of knowledge which are of more value to a manufacturer than that of science, but that is not a sufficient reason why the latter should be neglected. It may be of greater importance to him to have a manager who possesses a knowledge of workmen, and a good administrative power over them, than to have one who only understands the science of his manufacture; and it may be better for him to have a workman who understands the empirical methods of his trade, rather than one who knows only the science upon which those methods are based. Nevertheless, if English manufacturers are to successfully withstand foreign competition, they must employ workmen who can not only work, *but work to the greatest advantage.*

Not only is scientific education of advantage to a manufacturer, but it is also a national necessity; without it we are unable to fully economize the forces and materials employed in manufactures, or manufacture articles as cheaply as foreigners who bring scientific knowledge to their assistance. In some of the countries on the continent of Europe the national necessity of scientific education has been already recognized; not only is there a much more general diffusion of such knowledge in those countries than in England, but there is also a greater degree of State encouragement to scientific education. In Berlin a laboratory has been newly erected in the Dorotheen Strasse by the Prussian Government at a cost of 47,700*l.*, in Bonn another at a cost of 18,450*l.*, and in Leipsig a third large one is now being erected, at a cost of about 30,000*l.* In Carlsruhe, a noble building, the Polytechnic school, has also been erected, affording instruction to 600 science students. Having been over those buildings, and examined their internal arrangements, as well as the chief ones in this country, I can state that we have no laboratories, either erected by Government or by corporate bodies, which are equal to the foreign ones. Liebig, writing to Faraday, said, "What struck me most in England was the perception, that only those works which have a practical tendency awaken attention and command respect; while the purely scientific, which possess far greater merit, are almost unknown; and yet the latter are the proper and true source from which the others flow. In Germany it is quite the contrary." Germany possesses six purely technical universities specially adapted for the diffusion of "technical scientific education," whilst England does not possess one. It is a notable statement that "England spends five times as much on pauperism and crime as upon education; whilst Switzerland spends seven times as much upon education as on pauperism and crime." Each Englishman

may be said to have to continually carry a pauper and a criminal in consequence of our neglect of education. For all our artisans—and they number by millions—there exists no means of scientific education which would specially fit them for their future employments. The Universities and Colleges are not for them, and in ordinary schools the principles and technical relations of science are but little taught. If England is to successfully keep pace with the progress of foreign intellect and foreign manufacture, there must not only be a general diffusion of elementary secular knowledge throughout this country, but there must also be as great a degree of encouragement of scientific knowledge as exists in other countries.

The desire to withstand foreign competition, and to recover lost trade and manufacture, are not the highest motives why masters and workmen should be induced to acquire a greater knowledge of science. It would be a higher virtue, and much more praiseworthy in all men, if they pursued truth primarily for its own value, and for the sake of their own mental improvement, rather than for the immediate pecuniary advantages it may confer.

It was not by means of better scientific education that our superiority as a manufacturing nation over other countries was developed, and for many years maintained, but chiefly in consequence of our abundant supply of coal and iron ore, and the genius of a few scientific men in applying those stores to practical purposes in steam-engines, machinery, and a multitude of mechanical, physical, and chemical processes. Had it not been for these circumstances, England, like other nations not possessing such stores, would have been compelled a generation ago to have adopted an extensive system of scientific education. The knowledge of science which has enriched this nation was not acquired in schools; its possessors had to get it as they best could. Where did Faraday learn electricity? Where did Watt learn the science of heat? How did Arkwright learn mechanics? They all obtained their knowledge in spare moments, not in our public schools, because those subjects were not taught in them.

Arguments are not unfrequently adduced to support the opinion that ignorance has its advantages; but, however great the advantages of ignorance may be, those of intelligence are still greater. The extent to which in this country ignorance of the duties of an office is considered a qualification for filling it, is in itself a melancholy proof of our real want of education.

In consequence of the labours of scientific discoverers and inventors, the progress of science is such that in a very few years a knowledge of it will be indispensable to all persons engaged in superintending or carrying out manufacturing operations, and in all arts, occupations and appointments in which man is dealing with matter. Science is fast penetrating into all our manufactures and

occupations, and "those who are unscientific will have much less employment, and will be left behind in the race of life." England also will be compelled, by the necessities of human progress and the advance of foreign intellect, to determine and recognize the proper value of science as a branch of education.

The philosophy of matter is the foundation of all manufacturing arts and artistic processes; technical education, or the relations of science to manufactures, &c., can only be properly imparted upon the basis of a sufficient knowledge of theoretical science. An attempt to impart technical education without such a basis would be but a very imperfect improvement upon the present system of learning by the "rule of thumb" alone. It is true that our artisans can work and do work without scientific knowledge, but they cannot work to the greatest advantage; and it is precisely such knowledge they now so badly require. It would be difficult to state exactly how much of such knowledge should be imparted to intended workmen; but it should certainly include all the chief laws and principles of the sciences involved in their prospective employments. What persons in general, who are not intending to become teachers of science, require to learn, is rather the general principles and leading facts of science, and their relations to manufactures, than a large extent of science; the entire subject is altogether too great for them.

It is both unnecessary and undesirable that lessons in science should be entirely of an abstruse character, abounding in scientific terms difficult to understand. All such lessons should be freely illustrated by experiments, apparatus, models, processes, diagrams, drawings, and the use of the black-board; and the difficult terms necessarily employed in them should be fully explained. By selecting many of the illustrations from the applications of science in the phenomena of the material universe, of manufactures, and of every-day life, all the fundamental laws and principles of physical and chemical science may be readily made intelligible to the meanest intellect. By this method also, the theory of science and its practical applications may be simultaneously taught in the most natural and effective manner. In all scientific lessons to practical persons, suitable technical illustrations should be freely employed. Artisans have to deal, not so much with the laws and principles of substances and forces, as with the substances and forces themselves; and men who have to deal with matter and forces require not only the forms but the tangible realities of scientific knowledge. If an attempt is made to teach pure science alone without such illustrations, working-men and practical persons will not accept it, because they cannot perceive its application to their wants. What they specially require to be taught is, *how such knowledge is applied and operates in their several occupations.*

Each special manufacture usually involves the principles of

several sciences, including physics and chemistry; and therefore the employments connected with it, and the technical education relating to it, also necessarily include a knowledge and an explanation of the chief laws and principles of those sciences: for example, the manufacture and working in metals requires a knowledge of the sciences of mechanics, heat, and chemistry; the occupation of electro-plating necessitates a knowledge of electricity and chemistry; the numerous employments involving the construction or use of tools and machinery require a knowledge of the science of mechanics, and in some cases also of heat and chemistry.

The fundamental laws and principles of any particular science operate in a similar manner in all trades, and are substantially the same for all learners: for example, the same chemical and electric principles operate in the galvanic batteries of telegraphists and electro-platers, as in those of the scientific investigator; the laws of combustion are the same in a puddler's furnace as in a domestic fire-place; water boils at the same temperature, whether it be in a chemist's flask, a brewer's copper, or in a servant's saucepan; the laws and principles of science, therefore, cannot be readily subdivided to suit particular trades. With the practical illustrations, however, the case is different; they may be selected from particular occupations, manufactures, arts, processes, and substances, so as to make the lessons suitable for different classes of persons, and thus *by varying the kind of illustrations* the lessons may be adapted to persons of different occupations, to agriculturists, metallurgists, and others. In courses of lessons or lectures on technology, the teacher should be very careful to select as many of the illustrations as possible from the actual working experience involved in the particular trades or occupations of his audience, and in this way the highest science may be united to the meanest art. A difficulty connected with the carrying out of this plan is, technical processes are rarely well understood by professional teachers, because those processes depend so much upon practical details.

The technological teacher must know both the science of the manufacture and the details of the manufacture itself to which that science is applied; he must be able to combine theory and practice, and continually to show the relation of abstract laws and principles to technical results. He must not only know how difficult things are done, but he must also to some extent be able to do them, and thus to teach by example as well as by precept. His teaching must be full of practical applications and familiar illustrations. Such teachers are as yet almost unknown, and Faraday, in his evidence already referred to, stated that the class of men suitable for teaching science remained to be created.

This statement made by Faraday still remains true. Our Universities have not yet supplied many schools with teachers eminent

in physics or chemistry. The sudden public demand for some indefinitely understood scientific education has produced a supply of comparatively unqualified teachers, and those appointed in some of our schools have had only a book-knowledge of the subject, but little experience in making experiments, much less acquaintance with the relations of science to manufactures, and entirely without experience in original experimental research. The ignorance of some of the simplest practical scientific matters, shown by some of these otherwise educated gentlemen, has been quite astonishing, and the most charitable supposition is that they are unaware of their ignorance.

The kind of teachers required for communicating scientific instruction are not men possessed only of a book-knowledge of science, and the power of communicating it, nor even of men who have also repeated the experiments of others as described in books, but men who, in addition to all this, are familiar with the details of manufacturing operations, and have also had considerable experience in original experimental research, and thereby acquired the power of distinguishing truth from error in matters of science,—a quality of the highest value in teaching, and which cannot be acquired in any other way.

VIII. ATMOSPHERIC ELECTRICITY AND RECENT PHENOMENA OF REFRACTION.

By Samuel Barber.

Whatever connection may exist between earthquakes and electrical disturbance of the atmosphere — a connection remarkably substantiated during the past year—there seems little reason to doubt that there exists between the electric waves or currents and the condition of atmospheric vapour a close relation. The more we examine the various changes of cloud and mist, their multiform shapes and ever-varying tints, their changes in density, altitude, and attractive or repulsive power, the more are we convinced that a force of incalculable power and undefined extent, more subtle and scarcely less potent than that of gravitation is in constant operation upon them.

The operation to which I allude, that of electricity, both atmospheric and terrestrial, seems rather to have been studied in its exceptional manifestations, than as a force subject to law, and of vast and constant, though unobtrusive, influence. The difficulty of rendering this science deductive, in its relation to meteorology, is apparent; the collection of data and the progress of experimental research form our present basis.

Till something more is known, however, and known more definitely, as to the nature of cloud and fog constituents, we can scarcely expect much progress in this department; and I would commend the subject to aëronauts and microscopists. Mr. Proctor, in an interesting paper on the subject of rain,* quotes De Saussure, Kamptz, &c., against Sir J. Herschel and Tyndall, appearing to incline to the views of the latter writers. He does not, however, allude to electrical action in enumerating the causes of rain. Yet it seems to me there is no reason to believe that the aggregation or dissociation of clouds and the condensation of their particles is greatly due to the influence of this force. That the movements of cloud and mist are accompanied by strong electrical action has been shown by the experiments of Mr. Crosse, of Bromfield, and Mr. Ronalds;† and it is but reasonable to think that this action may have great influence on contiguous vapour, though unaccompanied by a disruptive discharge, or any luminous appearance. My observations induce me to think that electricity is also indirectly the cause of those peculiarities of refraction which depend upon the molecular condition of the vapour mediæ through which the light passes, *viz.*—Halos, Parhelia, Paraselenæ, &c.; and I may here remark that these phenomena appear to have been unusually abundant during the past year, which has also afforded such exceptional displays of aurora, &c.

On the 21st September, a halo, of large diameter, say 60°, corresponded in position with the cirrhus clouds which formed the refracting medium. This halo followed the irregularities of the cloud to a considerable extent. Its disappearance was almost instantaneous, being caused apparently by the approach of a large mass of cumulus in the lower region of the sky. Almost as soon as the latter touched the lower part of the circle, the halo vanished. The irregularities in the circle of light at one time took the form of a series of separate arcs, which bent inwards, and appeared to be composed of half-dissolved cirrhus. These irregularities of form were also very conspicuous in a remarkable halo which was seen on Friday evening, December 19th. This assumed a spheroidal form, and was intersected by streaks of cirrhus, which changed their form rapidly, and showed a prismatic refraction like that of the halo itself. The vanishing of the first-mentioned halo was perhaps caused by an alteration in the constitution of its crystals or vesicles resulting from the electric action of the cloud below.

The next appearance I have to describe was of a singularly beautiful form and perfect definition. It appeared imbedded in a mass of homogeneous vapour, and consisted of two distinct rings, the inner one of a deep cobalt blue. This ring was distant from

* 'Intellectual Observer,' December, 1867.
† *Vide* Sir S. Harris's 'Electricity.'

the moon's disc about three diameters. Its outline was clearly defined, especially towards the inner part of the circle, and the colour was exquisite in tone. Farther from the moon, by about two apparent diameters, there was another ring, less defined and wider than the first, and of a beautiful crimson colour. Altogether this was the most beautiful appearance of the kind that I ever witnessed. It occurred about 11½ P.M. on the evening following that on which the first-described halo appeared. All three were followed by drenching rain, lasting about a week in the first case. A gale came shortly after the second (December 19th). The cirrhus clouds which almost filled the sky resembled in form an appearance of aurora on this occasion, and had a peculiar motion, vanishing and reappearing in fresh forms, though there was no wind at the time.

NOTICES OF SCIENTIFIC WORKS.

FARADAY, HIS LIFE AND LETTERS.*

One of the prettiest spots on the rail between Lancaster and Leeds is the village of Clapham. Here the bold Yorkshire scenery loses its nakedness, the hill-sweeps are cultivated, and a winding stream runs through the somewhat wooded valley. At a considerable elevation the railway bridges this valley, and as the station is neared a few scattered stone cottages mark the commencement of the distant village. This is the ancestral home of Faraday, and here his family name is still to be found. The Clapham parish register of 1708 contains the earliest record of the family of our great philosopher in the person of one "Richard Ffaraday." After this we find that at Clapham Wood Hall, there lived a Robert Faraday, one of whose sons, James, became a blacksmith. Soon after his marriage, in 1786, James Faraday moved to London, and lived for a while at Newington Butts, where his third child, Michael, was born on Sept. 22nd, 1791. This Michael was afterwards the "Faraday" whose name is now a household word, and the lustre of whose fame time will increasingly brighten.

The stages of Faraday's early life are well known; how, from being a newspaper boy, he rose to be a bookbinder's apprentice, then to be the assistant, and finally, the successor of Davy. It would, however, hardly be thought likely that the quiet and simple life of Faraday would furnish sufficient materials for so extensive a biography as that which Dr. Bence Jones has compiled. But it must be remembered that Faraday's life was full of his own stirring discoveries, and forms the link between the scientific men of the past and those of the present. The true function of a biographer is to sink himself in his subject, and this Dr. Bence Jones has done in an eminent degree. Hence the work reads like an autobiography. It gives us a picture of Faraday's intensely active and penetrating mind, from which there flowed at first sagacious letters to his friends; then a journal of foreign travel, full of acute observation; then a record of his early work in the laboratory; then his early triumphs as a lecturer; and, when he had fully trained himself for the fight, his grand conquests over the secrets of nature. So that one reads on with an eager and almost breathless interest as Faraday hotly pursues his electrical researches, and goes from strength to strength in the mysteries he reveals.

The first traces of Faraday's greatness of mind are to be found in his letters to his early friend Abbott. This correspondence, to-

* 'The Life and Letters of Faraday,' by Dr. Bence Jones, Secretary to the Royal Institution. London: Longmans, 1870.

gether with his foreign journal, occupy the main portion of the first volume. Most heartily do we thank Mr. Abbott for having preserved these letters. With all Faraday's disadvantages of education, his letters, though often laboured, it is true, are written with an elegance and thoughtfulness of which anyone might be proud. When twenty-one years old, he wrote the following passage to Mr. Abbott, in which at that age his discernment is well seen. How many would do well to listen to these words:—"A lecturer falls deeply beneath the dignity of his character when he descends so low as to angle for claps, and asks for commendation. Yet have I seen a lecturer even at this point. I have heard him causelessly condemn his own powers. I have heard him dwell for a length of time on the extreme care and niceness that the experiment he will make requires. I have heard him hope for indulgence when no indulgence was wanted, and I have even heard him declare that the experiment now made cannot fail from its beauty, its correctness, and its application, to gain the approbation of all. Yet surely such an error in the character of a lecturer cannot require pointing out, even to those who resort to it; its impropriety must be evident, and I should, and perhaps have done well, to pass it."

The first lectures that Faraday delivered were given at the City Philosophical Society in 1816. These were prepared with all the careful assiduity which marked his subsequent work. From the notes of these lectures we glean what Faraday was at twenty-four. Here are his thoughts at the close of one of these lectures:—"The philosopher should be a man willing to listen to every suggestion, but determined to judge for himself. He should not be biassed by appearances; have no favourite hypothesis; be of no school; and in doctrine have no master. He should not be a respecter of persons, but of things. Truth should be his primary object. If to these qualities be added industry, he may indeed hope to walk within the veil of the temple of nature." More than fifty years have passed since these words were spoken, and now we perceive how perfectly Faraday himself realized this noble ideal.

From the journal he kept when travelling with Davy, we learn some interesting facts concerning the social as well as the scientific state of Europe at that time. Here, too, are to be found traces of his keen and accurate observation, of his humour, of his kindliness, and of his constant affection for those at home. In this journal one of the most valuable of his entries relates to the combustion of the diamond, a feat, it will be remembered, that Davy first accomplished at Florence by the aid of the fine lens belonging to the Grand Duke of Tuscany. Our readers may be glad of the extract:—

"To-day we made the grand experiment of burning the diamond, and certainly the phenomena presented were extremely beautiful and interesting. A glass globe, containing about 22 cubical inches, was exhausted of air, and filled with very pure oxygen, procured from

oxymuriate of potash; the diamond was supported in the centre of this globe by a rod of platinum, to the top of which a cradle or cap was fixed, pierced full of holes to allow a free circulation of the gas about the diamond. The Duke's burning-glass was the instrument used to apply heat to the diamond. It consists of two double convex lenses, distant from each other about $3\frac{1}{2}$ feet; the large lens is about 14 or 15 inches in diameter. The instrument is fixed in the centre of a round table, and is so arranged to admit of elevation or depression, or any adjustment required, at pleasure. By means of the second lens the focus is very much reduced, and the heat, when the sun shines brightly, rendered very intense.

"The instrument was placed in an upper room of the museum; and having arranged it at the window, the diamond was placed in the focus, and anxiously watched. The heat was thus continued at intervals for three-quarters of an hour (it being necessary to cool the globe at times), and during that time it was thought that the diamond was slowly diminishing and becoming opaque. . . . . On a sudden Sir H. Davy observed the diamond to burn visibly, and when removed from the focus it was found to be in a state of active and rapid combustion. The diamond glowed brilliantly with a scarlet light inclining to purple, and when placed in the dark continued to burn for about four minutes. After cooling the glass, heat was again applied to the diamond, and it burnt again, though not nearly so long as before. This was repeated twice more, and soon after the diamond became all consumed. This phenomenon of actual and vivid combustion, which has never been observed before, was attributed by Sir H. Davy to the free access of air. It became more dull as carbonic acid gas formed, and did not last so long. The globe and contents were put by for future examination."

Returning to England, Faraday was, in 1815, officially appointed to be chemical assistant at the Royal Institution. As such he continued for some ten years, when, having already given occasional lectures, first in the laboratory, and then in the theatre of the Royal Institution, he was permanently appointed to the position he held until his death. In 1816 Faraday published his first contribution to science in the then 'Quarterly Journal of Science;' this was rapidly followed by other papers on very diverse subjects, and it was not until 1831 he began the great work of his life, the 'Experimental Researches in Electricity.' It will be unnecessary to refer to these researches here, for our readers are probably acquainted with their magnitude and importance. Unswervingly were they pursued until, in 1855, he sent the thirtieth, and last, of the series to the Royal Society.

Remembering his even life, many are surprised that Faraday found it necessary to relinquish his great work at an age in which most of our statesmen are in their very prime. When, however,

we recall the intense application of mind and body necessary for the pursuit of physical investigation, and how for forty years Faraday sustained this unceasing drain of nervous energy, our surprise is only at his powers of endurance, and that it should have been possible for one man to accomplish so much. Up to the very end he worked, even when his memory was fading away and his powers of mind so exhausted that he had at frequent intervals to rest his brain, until, like a voltaic pile, the nervous force accumulated with sufficient intensity to effect a discharge of thought. At last baffled at every turn by the loss of memory, his experimental work only ceased when, after completing a tedious and unsuccessful investigation, he found he had done it all before, and obtained the results he now sought for in vain.

His last thoughts were turned to the possibility of correlating gravity with the other forces. And, with all deference, we beg to express our regret that the Royal Society refused his last paper, in 1860, "On the possible Relation of Gravity with Electricity and Heat." The results, it is true, were negative, but to publish what cannot be done is, in science, often as valuable as to publish the records of success. Here are some of the speculations that are to be found in Faraday's note-book at this period. Speaking of gravity, he says:—"Might not two globes (or masses, as pigs of lead), A, B, attached to the end of a long rope, passing over a large pulley at the top of the clock-tower, or in the whispering-gallery of St. Paul's, serve an experimental purpose? Starting with both balls insulated, discharged, and balanced, then it would be easy to raise B and lower A, and examination by a very delicate static electrometer might show A charged positive and B negative; then discharging both, and reversing the motion, B would come down positive, and A become negative, and so on. . . . . These electrometers being very delicate and of the condensing kind, one man, having only to turn a windlass, might work the apparatus for half a day, or it might be kept in motion by a steam-engine, or other mechanical power. The evolution of one electricity would be a new and very remarkable thing. The idea throws a doubt on the whole; but still try, for who knows what is possible in dealing with gravity?" He makes the trial with all his accustomed experimental skill, and though he fails he does not despair that others will obtain results that are denied to him.

In connection with this subject of the correlation of forces an important extract, from the notes of a lecture delivered by Faraday in 1834, is given on p. 48, vol. ii. The notes run thus:—"Now consider a little more generally the relation of all these powers. We cannot say that any one is the cause of the others, but only that all are connected and due to one common cause. As to the connection, observe the production of any one from another, or the conversion of

one into another." Then he states experiments, showing the conversion of chemical power into heat, into electricity, and into magnetism, and of the converse action in each case: after which he remarks:—"Even gravitation may perhaps be included. For as the local attraction of chemical affinity becomes attraction at a distance, in the form of electricity and magnetism, so gravitation itself may be only another form of the same power." Later in life Mr. Faraday initialed these notes and wrote 'Correlation of Forces.' Now Mr. Grove's 'Lectures on the Correlation of the Physical Forces' were delivered eight years subsequent to this. Hence priority of the idea unquestionably belongs to Mr. Faraday, whilst the masterly development that led to its speedy recognition was first accomplished by Mr. Grove.

The *chef-d'œuvre* of Faraday's researches is, in our opinion, that which led to the discovery of magneto-electricity. Both theoretically and practically its importance can hardly be over-estimated. It is well known that Faraday took a keen interest in all those developments of scientific discovery that benefited mankind. The writer well remembers the emotion with which Mr. Faraday spoke as he showed him a rod of iron that had been fused by a current of magneto-electricity, and explained the wonderful expansion of that power discovered by Mr. Wilde. Thirty years before, Faraday had seen the birth of that same electricity only in the convulsive twitch of the needle of his galvanometer. He lived to behold this child of his grow into a mighty power; he saw it everywhere employed and fortunes founded on its free use; he saw it adapted for telegraphy, and the luxury of private telegraphs made possible by its means; he saw it used on a grand scale for electro-metallurgy; he saw it generating ozone, and thereby refining sugar; he saw it make iron run like water; he saw its light used by the photographer to enlarge his negatives; and finally, he saw it shine like a midnight sun over the reefs around our coast. It is sad for our country's honour to know that the genius who laid the foundation of this prosperity was all his life long supported by a private institution, which never could afford to pay Faraday so much as he would have earned had he been a bank-clerk. It is humiliating to read how, when Faraday was rising to the zenith of his fame, the Committee of the Royal Institution were only able to report that "certainly no reduction could be made in Mr. Faraday's salary of 100*l.* per annum, with rooms, coals, and candles." And though, happily, Faraday found his highest reward in the pleasure of his work and in the kindly esteem of his fellow-men, nevertheless he keenly felt how little our nation care to recognize deep philosophical pursuits. Writing to Lord Wrottesley, he says,—"For its own sake the Government should honour the men who do honour and service to their country. I have, as a scientific man, received from foreign countries and sovereigns honours

which surpass, in my opinion, anything which it is in the power of my own to bestow." What those honours were we had intended to state, but their astonishing number, some sixty or more—a number we believe quite unparalleled in the annals of science—would have occupied more space than we can spare.

In conclusion we must repeat our high opinion of the manner in which Dr. Bence Jones has compiled this record of Faraday. It has been a work of labour, but manifestly a labour of love. We wish the public would read this memoir. It would be well for themselves, and it would be well for the progress of science. No one can rise from the perusal of this work without feeling the better for knowing more of one who, as the following picture will show, embodied both "sweetness and light."

"As a philosopher, Faraday's first great characteristic was the trust which he put in facts. His second great characteristic was his imagination. It rose sometimes to divination, or scientific second sight, and led him to anticipate results that he or others afterwards proved to be true.

"As a man, the beauty and the nobleness of his character were formed by very many great qualities. Among these the first and greatest was his truthfulness. His noble nature showed itself in his search for truth. He loved truth beyond all other things; and no one ever did, or will, search for it with more energy than he did. His second great quality was his kindness. It was born in him, and by his careful culture it grew up to be the rule of his life; kindness to every one always—in thought, in word, and in deed. His third great quality was his energy. This was no strong effort for a short time, but a lifelong lasting strife to seek and say that which he thought was true, and to do that which he thought was kind.

"That one who had been a newspaper boy should receive, unsought, almost every honour which every republic of science throughout the world could give; that he should for many years be consulted constantly by the different departments of the Government, and other authorities, on questions regarding the good of others; that he should be sought after by the princes of his own and of other countries; and that he should be the admiration of every scientific or unscientific person who knew anything of him, was enough to have made him proud; but his religion was a living root of fresh humility, and from first to last it may be seen growing with his fame, and reaching its height with his glory, and making him to the end of his life certainly the humblest, whilst he was also the most energetic, the truest, and the kindest of experimental philosophers."

Such was the man of whom England has not seen his like since the time of Newton. A true Christian gentleman, a great High Priest of Nature was Michael Faraday.

Geology and Revelation: or the Ancient History of the Earth considered in the Light of Geological Facts and Revealed Religion. By the Rev. Gerald Molloy, D.D. London: Longmans & Co. 1870. 8vo. Pp. 418.

It is no small credit to our Established Church that some of her best men have been also noted as our most able geologists.

Buckland, Conybeare, Henslow, Whewell, Sedgwick, and many others, have done credit alike to the Gown and to the Hammer.

Nor have the clergy of other denominations failed to furnish illustrations of geological workers and writers. The Rev. David Ure, the Rev. Dr. John Fleming of the Scotch Church, and the Rev. J. McEnery,* a Roman Catholic clergyman at Torquay, have largely aided in the promotion of geological science.

The author of the present work is also a Catholic clergyman and Professor of Theology in the Royal College of St. Patrick, Maynooth; where, being engaged in expounding the evidences of revealed religion, he met with difficulties in reconciling with them certain geological phenomena and speculations. He therefore resolved to make himself acquainted with the leading facts of the science, and for this purpose consulted the works of our great geological masters. He determined to consider the subject "in a candid and philosophical spirit," being, *however*, "impressed with the conviction that no fact can be really at variance with revealed truth."

The results of his inquiry he offers to those who, feeling like himself the necessity of it, have no time nor opportunity to pursue such an investigation.

In the present volume, Dr. Molloy treats of the bearing of the great antiquity of the earth, with the history that is given in Genesis. In a future volume he hopes to discuss the antiquity of man. His work is divided into two parts. The first is devoted to an outline of geological facts and phenomena. Contrary to the majority of authors who have treated of geology and religion, Dr. Molloy displays a very good knowledge of geological science, and this summary, which is written in a similar style to Page's 'Geology for General Readers,' can be read with advantage by those for whom our manuals afford too much dry detail. It contains the essential facts of geology, and is very agreeably written.

The second part of the work, the conclusions of geologists, are compared with the "truths of revelation." Dr. Molloy endeavours to adapt the periods of geology to the six days of Genesis—a sub-

* Mr. McEnery's name will always be associated with the earliest exploration of Kent's Cavern, and the finding of human remains (in 1824–5) associated with hyæna, &c., in undisturbed deposits beneath the stalagmitic floor of this now historic cave.

ject that has already led to the publication of so many speculative books.

The chronology of the Bible, he admits, does not go back to the beginning of the world. There may have been, he thinks, a long interval of time between the creation of the world, and the work of the six days. He regards the six days as probably of indefinite, though not necessarily of unequal length, and proceeds to arrange the geological formations into six divisions to indicate the different work done on each of the days. Apparently the seventh day is going on at the present time. Taking the history of organic life into consideration, he regards plants and trees as created on the third day (= Carboniferous Period); reptiles, fish, and birds on the fifth day (= Cretaceous, Jurassic, and Triassic Periods); and the beasts of the earth, including man, on the sixth day (= Tertiaries, &c.). The other three days were devoted to light, sun, moon, stars, &c., and we must not expect to find geological indications of them.

Respecting the fact that organic life, both plants and animals, prevailed upon the earth for many ages before the Carboniferous Period began, we need do no more than quote Dr. Molloy's ingenious answer:—"The sacred writer tells us, no doubt, that on the third day God created plants and trees; but he does not say, either expressly or otherwise, that previous to the third day the earth was devoid of vegetation.

"Again, we read that reptiles, fish, and birds were created on the fifth day. But there is nothing in the language of the inspired narrative from which it can be inferred that these several classes of animal life may not have been represented, before that time, by many and various species: though, probably, it was only on the fifth day that they were developed in such vast numbers, and assumed such gigantic proportions, as to become the most conspicuous objects of creation."

We have, in the foregoing brief notice, given some idea of the scope of Dr. Molloy's volume. If we could see the feasibility of arriving at any close agreement between geological facts and the history given in Genesis, we should welcome such a volume as this one, coming as it evidently does from an able and candid writer. But when a strained interpretation has to be put upon the one history so as to make it accord with the other, and especially when it is found needful to adopt such explanations as that above quoted, we cannot but feel that this, as well as almost every other attempt at dividing geological time into the procrustean limit of six periods, representing the six days mentioned in Genesis, helps us in no way towards a satisfactory concordance between the testimony of Moses and the testimony of the rocks.

A perusal of the first part of Dr. Molloy's work—especially the very impartial manner in which he discusses the facts and deductions

arrived at by geologists—gave us a very favourable opinion of the book. We were disappointed, however, with the second part, and can only regret that the author has not done equal justice to the theological side of the question, if it can be said to have a theological side.

The question very naturally arises in our mind, Why should theology and geology be reconciled? has the one any ground in common with the other? The Bible was never intended to teach geology, nor the rocks ever intended to teach theology, save that they speak of unity of design, and uniformity of action in creation from the earliest times to the present day.

CHRONICLES OF SCIENCE,

Including the Proceedings of Learned Societies at Home and Abroad; and Notices of Recent Scientific Literature.

1. AGRICULTURE.

The sewage question has had its full share of attention during the past quarter. Before the Institution of Surveyors, the Society of Arts, and the London Farmers' Club, town sewage has been discussed as a possible source of profit to agriculturists and to ratepayers: and in the Report of the Rivers Pollution Commission, just presented to Parliament, it is discussed as a nuisance to be abated. In this report the agricultural remedy for the nuisance, being the only one by which it may be made a source of profit, is held out as trustworthy and efficient—but other remedies are also pointed out. Filtration—not the mere action of a sieve upon suspended matters, but filtration of the kind which venous blood undergoes when passing through the lungs—is a satisfactory remedy. If sewage be passed in an intermittent way downwards through a sufficiently capacious filter, displacing at each access the air with which the filter becomes filled in the intervals, it undergoes a thorough oxidation, and comes out with all its organic matter oxidized and rendered harmless. In this way, however, not only is a nuisance abated, but a valuable property is destroyed. All the agricultural analogies point to the fertilizing character of town sewage. Man ought to be as useful a species of farm stock as sheep. Everybody knows the fertilizing effect of the sheepfold. The 20 millions of sheep in England are the very safeguard of the permanent fertility of all our light soils. The 20 millions of "man"—for the two animals are singularly alike in number and weight—ought to be at least as valuable to the farmer. At present, man as farm stock is almost good for nothing. No doubt, the lesson which we are learning of his agricultural value at Edinburgh, Aldershot, Barking, Banbury, Warwick, Rugby, Bedford, Croydon, Norwood, Worthing, and elsewhere, will ultimately convince both town and country of the waste that is being now incurred. Perhaps the enthusiasm of those who believe in it, as well as the *vis inertiæ* of the incredulous, has had something to do with the dilatoriness of public opinion on the subject. It has been supposed that sewage will overrule the influence of climate, soil, and even the specific character of plant and animal. This however is a mistake. The proper conclusion is, that for most ordinary English agricultural crops of succulent growth, sewage, applied with discretion, is of unequalled fertilizing power; but for crops to which our climate is

of only occasional and doubtful fitness, sewage, like other manures, will produce only occasional or doubtful results. The life and character of a plant are, in fact, an unalterable "quantity" in all agricultural calculations. They may be improvable within very narrow limits; but no enthusiastic belief in the power of any new agency in agriculture should blind us to the fact that, however animals and, *a fortiori*, men, who are capable of influence by many other motives besides the merely material ones, may improve under education, plants have very limited capacities indeed. We may educate our animals to some extent to bear with and perhaps to profit by an unaccustomed set of circumstances, but plants must be simply *selected* for their ascertained natural aptitudes. Happily there are plants enough for which our climate is well adapted by which we can most perfectly utilize the agency of sewage. Italian ryegrass, mangold wurzel, cabbages, celery, asparagus, and strawberries all prosper wonderfully under its influence; and even grain crops, judiciously treated, will answer satisfactorily to the sewage whip. We may hope, therefore, soon to see a profitable and wholesome conversion of town drainage, now so great a plague, into useful agricultural produce—good milk and vegetables, or even strawberries and cream!

The question of manure adulteration has occupied the attention of the Royal Agricultural Society of England, whose chemist, Dr. Voelcker, is now authorized to publish every month all analyses of adulterated foods and manures which pass through his hands: and accordingly several very glaring instances have been gibbeted in this way of worthless guanoes and superphosphates, in which gypsum, earth, chalk, and sand figure in place of the genuine ingredients of imported guano and bone-ash. This exposure of the risks which the farmer incurs by incaution in the manure market is the more necessary, when his success now more than ever seems to depend on brains and bones—his own brains, as the 'Agricultural Gazette' says, and somebody else's bones!

The current number of the 'English Agricultural Society's Journal' contains an interesting report of Belgian agriculture, from which, however, we do not gather any justification of the opinion which has hitherto been prevalent, that the small farming of that country is the best agriculture in the world. Of other communications which the Journal lays before its readers, we may name Dr. Voelcker's elaborate investigation into the value of beet pulp, the refuse of the beet-sugar manufacture, and his report of experiments which appear to indicate the usefulness of potash salts in manure for mangold wurzel. There are also reports on the cheese farms of Cheshire and on the American cheese factory system. Mr. Bailey Denton also calls attention in its pages to the possibilities of village sanitary economy in respect of water supply, cottage

building, and drainage. And the Rev. J. Stratton calls attention to the social circumstances of the agricultural labourer, and the possibility of a comfortable maintenance for him without the aid of the poor law.

Among other subjects which have occupied the attention of farmers, both in agricultural periodicals and at the meetings of agricultural societies, have been—the management of grass lands, discussed before the London Farmers' Club; the influence of the moon on weather, plants, and animals, which was very fully discussed (the prevalent idea on the subject being shown to be mere delusion), before a Dorsetshire farmers' club; the impolicy of the game laws, and especially of the reservation of hares and rabbits on the part of the landowner; the need of some acknowledgment of tenant-right on the part of landowners in England as well as in Ireland, where the principle is fully acknowledged in Mr. Gladstone's Irish Land Bill; the prevalence of pleuro-pneumonia and foot-and-mouth disease among cattle, which has been very unusual both as to extent and as to severity; and the policy of improving the means of education for the agricultural labourer. The introduction of a Government Bill on elementary education—by which local authorities are required to enforce the attendance at public elementary schools of all children under twelve years of age who have no reasonable excuse for their absence—is a matter of great agricultural importance. Such a measure cannot fail to tell most beneficially upon the next generation of both labourers and their employers.

The agricultural statistics of the country for 1869 have been published during the past quarter. They indicate a considerable reduction in the number of farm live-stock. There were 70,000 fewer cattle, 350,000 fewer pigs, and no less than 1,110,000 fewer sheep in 1869 than in 1868. The horse stock has been this year for the first time enumerated, and we now learn that we have 1,141,996 farm horses at work in England, 1,561,061 altogether in Great Britain. and close on 2,000,000 in the whole United Kingdom. Turning to the crop reports, about 340,000 more acres are returned as being in the hands of English farmers in 1869 than in 1868—23,370,639 acres in England, and nearly double that amount in the United Kingdom. There is an increase in England in the area of all grain crops amounting to 20,000 acres of wheat, 84,000 acres of barley, 22,000 acres of oats, 14,000 acres of rye, 45,000 acres of beans, and no less than 100,000 acres of pease. The clover crop was less in 1869 than in 1868 by no fewer than 365,000 acres, that being no doubt the extent which was ploughed up and sown chiefly with pease, but also with other crops, in consequence of the failure due to the drought of the year before last.

2. ARCHÆOLOGY (Pre-Historic).

To whatever country the white man goes he carries with him, in addition to the blessings of Christianity, a string of evils which, sooner or later, destroy the aborigines from off the face of the earth. Alcohol, fire-arms, clothes, small-pox, measles, and many other noxious accompaniments of civilization have done their work upon the aborigines of America (as they have on those of Australia, Tasmania, and New Zealand), but the last fatal blow seems to have fallen upon them in the opening of the Great Pacific Railroad from New York to San Francisco. That which we hail as the harbinger of peace and good-will to men, this great highway for the nations, 3300 miles in extent, sounds the death-knell of the Pawnees and the Sioux, the Crows, the Arrapahoes and Cheyennes, as certainly as it threatens death to Mormonism. Both will in a few years be swept away.

Mr. Frederick Whymper, giving an account of the line in 'Illustrated Travels,'* says,—" In the neighbourhood of Cheyenne there is a large military station, Fort Russell, where some 900 soldiers of the United States' army are quartered, expressly for the benefit of the Sioux and those 'dogs of Indians,' the Cheyennes. The railroad lost some excellent engineers by the hands of the latter when the preliminary surveys for the line were being made. General Sheridan was enabled to surround several of their villages last winter, and killed and subdued a large number of them. Several hundreds thereby left this world for happier hunting-grounds. The General had the reputation, however, of treating the women and children with great humanity." † This is a sad picture to contemplate; but sooner or later the same thing will occur in New Zealand. In Tasmania one solitary old woman, named "Lalla Rookh," represents the last of the aborigines! The natives of Australia are driven into the wilderness. All the good and pleasant places, once their own, are occupied by our countrymen.

Dr. Haast has communicated to Professor Owen an interesting account of the discovery, in the province of Canterbury, New Zealand, of several cooking-pits and kitchen-middens, containing the remains of various species of *Dinornis*. Such conclusive evidence of the contemporaneity of this now quite extinct bird with man in this island is most valuable to the ethnologist, and leads him to hope for fuller details.

Mr. F. Spurrell has lately obtained from the neighbourhood of Dartford, Kent, several flint implements of the palæolithic type.

* Part XIV. Edited by H. W. Bates, Assistant-Secretary to the Royal Geographical Society. London: Cassell, Petter, and Galpin.

† Page 34.

At the Archæological Institute, Mr. Soden Smith recently (Dec. 3) gave an account of a Circle of Stones in Crosby, Ravensworth parish, Westmoreland. This was remarkable as being composed of three concentric circles, and having also an avenue of stones 112 yards in length leading to it, and two smaller groups of stones lying close to it.

The Rev. Greville Chester described the shell-implements and other antiquities of Barbadoes. These shell-implements occur in old raised benches, and are often very abundant; they are formed from the columella of *Strombus gigas*.

Ethnological Society.

President, Professor T. H. Huxley, LL.D., F.R.S. Lieut. Oliver, R.A., has laid before this Society (Dec. 7) an excellent Report on the Pre-historic Monuments of the Channel Islands, of which he has communicated the most interesting features in the first article in our present number. An ancient Calvaria, assigned to Confucius, was exhibited and described by Professor Busk. This calvaria was formerly set in gold and mounted on a tripod, and intended for a drinking vessel. It was taken from the Emperor of China's Summer Palace at Peking. Four figures have been discovered upon the skull in faint relief. The president (Professor Huxley) mentioned that the Australians still use calvariæ ornamented in a like manner. Major Millingen communicated an account of the "Koords and Armenians," and identified the modern Koords with the ancient Karduks mentioned by Xenophon. The language spoken in Koordistan is distinct from either Turkish or Persian, and is divided into numerous dialects. The Koords are described by the author as a wild and faithless people, rejoicing in plunder and slaughter, the females engaging in brigandage. As a race they are remarkably handsome, and exhibit a great variety of complexion, a dark skin with black hair and black eyes being most common; light hair and blue eyes however are also met with.

On January 11, Colonel Lane Fox gave an account of the "mere," or "pattoo-pattoo" of New Zealand, showing that it is used as a weapon for thrusting, not as a club; the author believes it to be a modified stone celt, as a series of transitional forms may be traced connecting the two implements. Colonel Lane Fox's opinion is confirmed by a letter from the Rev. J. W. Stack, of Kaiopoi, to Dr. Hooker, C.B., explaining that the "mere" is always used for thrusting, not for striking.

Dr. Haast, F.R.S., sends details of the discovery in New Zealand of a polished stone chisel and a sharpening stone, found by a party of miners, in an auriferous "lead." Advancing inland, from the

present shore, several distinct belts of land (old sea margins?) may be observed, each characterized by its own peculiar vegetation; it was in the fourth of these belts, at a distance of 525 feet from the present high-water mark, that these implements were found. Although the polished implements are more highly finished than the rude chipped weapons hitherto found in or near moa-ovens,* the author considers they may have been used simultaneously by two races co-existing in the island, the more civilized using polished tools and dwelling on the coast, whilst the ruder primitive race retreated inland, retaining the use of their unpolished implements.

Dr. Oppert gave an account of a small race, numbering only about 50,000 souls, and known as the "Kitai," or "Kara-kitai," dwelling near the Caspian Sea, in the Russian Government of Derbend, and in the Siberian district of Guldja. These are the last descendants of a once powerful race, which ruled over China and Central Asia; one of their princes, Yelintashe, the author identified with the celebrated Prester John.

On January 25, Mr. Bonwick gave a paper "On the Origin of the Tasmanians Geologically considered," in which he sought to explain the distribution of many of the dark-skinned races in the southern hemisphere by an ideal southern land from whence they may have radiated. Dr. Hooker pointed out that man and the higher animals probably did not pursue the same line of migration as that followed by plants; and Professor Huxley suggested that a chain of islands may have formerly extended from New Caledonia to Tasmania, similar to that which now extends from New Guinea to New Caledonia, and that by this means a low Negrito type might have spread eastwards over this area.

Two papers followed: by Mr. Howorth, "On a Frontier-line of Ethnology and Geology," and by Mr Atkinson, "On the Nicobar Islanders." Mr. Atkinson exhibited some grotesquely-carved wooden figures brought from the Nicobar Islands by Captain Edge.

On February 8, Mr. W. Boyd Dawkins gave the history of a find of flint-flakes, and flakes of chert discovered in the angular *detritus* beneath a submerged forest at Porlock and Minehead, West Somerset. These objects of human workmanship prove that man must have existed on this old land-surface before the destruction of the forest and the accumulation of the series of overlying deposits. The author considered these flakes to belong to an early stage in the Neolithic period. Dr. A. Campbell read some notes on the remains of pre-historic man found in the neighbourhood of the Crinan Canal, Argyleshire. The Rev. Mr. Mapleson described these remains, which comprise some curious cup-shaped cavities and concentric rings rudely sculptured on certain stones; there are also menhirs and numerous cairns; crannoges have been found in most of the

* See Chronicle of Archæology for October, 1869, p. 513.

lochs, but they are usually solitary dwellings. Several duns, a vitrified fort, a brough, and a flint manufactory were also enumerated among the remains met with in this district. In connection with Professor Busk's paper "On a Calvaria" (read Dec. 21), that gentleman, on the 22nd February, exhibited another calvaria from China, lent by Dr. Lockhart. This skull is mounted in copper, and was formerly supported on a tripod and furnished with a lid.

On the same evening Mr. C. Monkman gave an account of "Discoveries of Archæological interest in recent Deposits in Yorkshire." Worked flints have been met with in the clay of Kelsea Hill. Large finds of stone implements of neolithic type are said to have been made in the York sands. Many implements have also been found in the old river-deposits in the Vale of Pickering, opened for land-drainage works.

A paper by Dr. Jagor, the well-known Eastern traveller and author, was then read, "On the Natives of Naga, in Luzon, Philippine Islands," in which the author described in detail the manners and customs of the Bicol Indians inhabiting this locality.

Anthropological Society.

Dr. Beddoe, President. Dec. 7, Dr. Leitner described his visit to Dardistan in 1866, and gave some account of the Shina race. Although the Dards were at war with the Maharajah of Kashmir, Dr. Leitner was able to keep up friendly relations with them during his stay at Ghilghit, and to collect much material relative to the hitherto unwritten Dardoo dialects. The customs of these peoples differ greatly from those of Mohammedans or Hindoos. They do not appear to possess any religion or rites, save the placing of a stone by each person annually on a cairn. Their food was stored in caverns, each family possessing its separate depository.

Dec. 14. Mr. Wake, "On the Race-affinities of the Madacasses," argues for the unity of origin of the light and dark tribes inhabiting Madagascar, both the Hovas and the other race having a common language and customs. Mr. Wake thinks Madagascar must formerly have been connected both with the African continent and the Malay Archipelago. The natives possess the ox, the sheep, and fowls in a domesticated condition (the dog is not mentioned); they have also a knowledge of smelting and working iron. The author conjectures that Madagascar was perhaps the seat of man's primitive civilization.

On the 4th January Mr. L. Owen Pike, M.A., communicated a paper "On the Psychical Elements of Religion." The author discussed the elements of popular creeds; the religion which appeals to the emotions and to the intellect; the religion of the astrologers; the personification of natural objects and forces, human passions

and human faculties; brute worship; the worship of humanity; the philosophic creeds, and their connection with popular creeds, &c. The Ethnological Society announced by their Honorary Secretary, Colonel Lane Fox, that a statement which had been published to the effect that the Ethnological Society was about to be wound up, was unfounded. That Society owed nothing, and was never in a more flourishing condition.

The Annual General Meeting of the Anthropological Society was held on the 18th January, Dr. John Beddoe, President, in the chair. The Society is at present overshadowed with the loss it has so recently sustained in the death of its most active promoter and founder, Dr. James Hunt. No anniversary dinner this year cheered their proceedings. Those philanthropic souls who labour only to promote the happiness and freedom of mankind would have listened with pain on February 1st to Major F. Millingen's account of "Negro Slaves in Turkey." These unfortunates are brought from the countries situated on the higher basin of the Nile,—the Nile-valley being the route followed by the cargoes of slaves on their way to the markets. Major Millingen considers that so long as the demand and supply exist it is useless to hope that slavery can be abolished. The endless feuds of the Negro races keep up the supply, and the religious and social system of the Mussulman nation causes the demand. Sir Samuel Baker's expedition to put a stop to the slave trade will, the author considers, prove futile unless the Sultan and the Khedive intend really to do away with slavery, which the Major thinks cannot be accomplished unless they give up their harems.

At the meeting of Anthropologists, on February 15th, Dr. Barnard Davis and Mr. E. A. Welch gave an account of "The Aborigines of Chatham Islands." The aborigines of these three islands, which lie to the eastward of New Zealand, have been gradually exterminated by the invasion of the Maories. Dr. Barnard Davis gives the result of an examination of the skulls and skeletons of many of the inhabitants. The stature of the Moriories, or Chatham Islanders, indicated a race shorter and stouter than the inhabitants of New Zealand.

Dr. J. Campbell contributed a paper "On Polygamy: its Influence in Determining the Sex of our Race, and its Effects on the Growth of Population." The author, who had been many years resident in Siam, concludes that the proportion of males and females born were, as in the case of monogamist marriages, entirely equal.

Mr. Ralph Tate described an inscribed rock on the banks of the Iguana, a tributary of the Orinoco, presenting incised markings of a date more ancient than the present inhabitants of the district.

3. ASTRONOMY.

(*Including Proceedings of the Astronomical Society.*)

The dismissal of M. Leverrier from his position at the head of the Imperial Observatory at Paris has not surprised those who have been familiar with the progress of events under his *régime*. By his rough and uncourteous manner he had alienated the good-will of his colleagues and subordinates; while by restrictions conceived in a jealous spirit he interfered with the progress of their labours. Recently he had given more tangible cause of offence; and the *astronomes adjoints* took advantage of the lapse to bring a statement before the Minister of the Interior, in which the conduct of Leverrier throughout his administration was discussed at great length. They finally submitted to the Minister the choice of dismissing Leverrier or accepting their resignations. After a brief consideration, he selected the former alternative, and M. Delaunay has been appointed to succeed Leverrier in the important position of Imperial Astronomer.

Though one cannot but regret that so distinguished and skilful an astronomer should have been thus dismissed from a post for which in a scientific sense he was so well fitted; it cannot be doubted that the punishment was well merited. No scientific ability, however eminent, can be pleaded in justification of a line of conduct by which scientific interests suffer.

Mr. Lockyer has communicated to the Royal Society an interesting paper "On the American Eclipse Observations." He quotes a letter of Dr. B. A. Gould's to show that the evidence afforded by the photographs suggests that the radiance seen around the moon is not the corona at all, but actually the image of the chromosphere. This is shown by many different considerations. The directions of maximum radiance do not coincide with the great beams of the corona; they remained constant also, whereas these last were variable. "There is a diameter approximately corresponding to the solar axis, near the extremities of which the radiance on the photographs is a minimum, whereas the coronal beams in these directions were especially marked during a great part of the total obscuration. The coronal beams also stood in no apparent relation to the prominences, whereas the aureole seen upon the photographs is most marked in their immediate vicinity." In this paper Mr. Lockyer expresses the opinion that the corona, as he has before suggested, is merely an atmospheric phenomenon, though he fails to show how the atmosphere which lies between the eye and the region near the eclipsed sun can be illuminated, or why, supposing it to be so, the glare should not trench on the moon's disc. According to ordinary optical considerations the blackness of

the moon on the corona would indicate that the glory of light comes from a region beyond the moon.

Professor Tait has put forward a theory respecting comets' tails which deserves mention, though it can hardly be accepted as explanatory of even the more ordinary cometic phenomena, still less of the abnormal phenomena which many comets have presented. He considers that the visibility of a comet's tail may depend on the position of the earth with respect to the plane in which the meteoric components of the tail are travelling. When the lines of sight from the earth are directed at a considerable angle to this plane, the tail would scarcely be visible at all; but when the earth moves into any plane touching the surface in which the meteoric particles are for the moment mainly gathered, the tail becomes visible at once along its entire length, "just as a distant flock of sea-birds comes suddenly into view as a dark line when the eye is brought by their evolutions into the plane in which they fly." Professor Tait does not show that the appearance of any comet's tail *has* corresponded to the earth's assuming such a position as he describes; and there is a further objection to his theory in the fact that the tails of many comets have been visible for months at a time, whereas the earth cannot have been so long in the plane of meteoric aggregation unless that plane coincided with the ecliptic, which has not been the case in any known instance.

Dr. Balfour Stewart has brought before the Astronomical Society certain views respecting the "Aurora," which belong more properly to the Chronicle of Physics than to that of Astronomy. But a suggestion thrown out in that paper as to the nature of the Zodiacal Light must not be left unnoticed here. He asks whether this Light may not be a terrestrial phenomenon—as Mr. Lockyer has suggested. "When once the anti-trades have reached the upper regions of the atmosphere, they will become conductors from their tenuity; and as they pass rapidly over the lines of the earth's magnetic force we may expect them to be the vehicles of an electric current, and possibly to be lit up as attenuated gases are when they conduct electricity. May not these form the Zodiacal Light?" The answer to this question cannot but be negative. A phenomenon which rises and sets, which occupies in all latitudes a definite relation to the fixed stars—in respect of position, cannot by any possibility be a terrestrial one. The region of the counter-trades may perhaps be lit up as Dr. Stewart suggests; if so the whole sky would show the light, and we have here perhaps a satisfactory explanation of the phosphorescent light often visible over the whole heavens at night. But the counter-trades cannot throw a tongue of light over a definite region of the celestial sphere, nor can they regularly *set* on spring evenings and as regularly *rise* on autumn mornings.

In a paper communicated to the Royal Society, Mr. Proctor describes a peculiar motion of the stars, which he terms *star-drift.* According to the accepted theory of stellar distribution, it would follow that among the stars visible in any given region of the heavens there should be proper motions in all possible directions, and ranging through all orders of magnitude from zero to a certain definite maximum. In place of this, Mr. Proctor finds that in many regions of the heavens the stars exhibit a certain community of motion, which seems to indicate that they form a set or system travelling bodily in a definite direction.

During the next quarter Jupiter will not be favourably visible, as he will be in conjunction with the sun on May 24th. Saturn, however, coming to opposition on June 16th, will for several months be a fine object for the telescopist. The rings are now at their full opening, and though the planet will be low down, yet in favourable weather it may be studied with advantage. Venus will reach her greatest westerly elongation on May 4th, but her apparent diameter is rapidly diminishing.

The solar spots are now very numerous, and for the coming months the sun should be very carefully studied.

Proceedings of the Astronomical Society.

Mr. Paine supplies an account of the total eclipse of August 7, 1869, which he observed in Boonesboro, Iowa. He noticed that the corona was not as striking as the one seen during the eclipse of November 30, 1834, nor was the darkness so great. He also remarks that the prominences were much more distinct last August than in 1834. He quotes the opinion of one who saw the total eclipse of 1806, that then also the flames were inconspicuous, and the darkness greater.

Commander Ashe describes the eclipse as seen in Canada; and Mr. Webb communicates an account of the work done by Professor Mayer in photographing the same eclipse. It is needless to enter into particulars respecting this communication, since, in a paper by Mr. Crookes in the last number of this Journal, a full account has been given, not only of Professor Mayer's work, but of that done by other photographers.

Mr. Alexander Herschel discusses certain irregularities presented during recent appearances of the November meteors. Observations seem to indicate the existence of two meteoric currents bordering upon the main-stream, but separated from it by blank spaces almost entirely devoid of meteors, and forming lateral outliers of the stream, near to which they appear to move in parallel and closely-adjacent orbits. "The passage of the earth through the

first of these outlying streams occurs about twelve hours earlier, and its passage through the last about twelve or fifteen hours later than its appulse with the main or central current." From other communications respecting the November meteors, as seen last autumn, it would appear as though the distance of the outlying or lateral streams from the main zone had become very much greater, with the advance of the meteors over one year's arc.

Mr. Proctor supplies a note "On the Sun's Motion in Space, and on the relative Distances of the Fixed Stars of various Magnitudes." It had been noticed by Mr. Dunkin that when the sum of the squares of the stellar proper motions is compared with the sum of similar squares corrected for the effects attributed to the sun's motion, the effect due to the correction does not appear to be so large as was to have been expected. In fact the former sum is 142·0251, while the latter is 136·4917, the difference being altogether insignificant compared with either. Sir John Herschel had expressed the opinion that this result need not surprise us. "If the sun move in space, why not also the stars? and if so, it would be manifestly absurd to expect that any movement could be assigned to the sun, by any system of calculation, which would account for more than a very small portion of the totality of the observed displacements." Mr. Proctor shows, however, that the mere number of the stellar movements will not suffice to explain the discrepancy, since the motion of each other is affected by the sun's, and so the sum of the corrections is as much increased (through the effect of mere number) as the sum of squares. By aid of the integral calculus he proves that the correction should in effect be one-half of the uncorrected sum. He explains the discrepancy as due to the fact that the stellar distances have been incorrectly dealt with, the distances of the smaller stars being overrated. He finds in the observed proper motions of the smaller stars an independent proof of this.

Dr. Robinson suggests an ingenious method of imitating the transit of a planet over the sun. He obtains an artificial sun by placing a plate of brass, in which is a circular aperture, in the focus of a telescope. When this is illuminated by a lamp placed behind it, and viewed collinator-wise, it appears as a luminous disc 17′ in diameter. He obtains an artificial planet, either (1) by means of a small opaque disc, carried by the frame of a micrometer in the observing telescope, or (2) by means of an opaque disc placed within the aperture, and movable in its plane by a micrometer attached to the collinating telescope.

Mr. Stone supplies a paper on the increase of probable errors in a transit of Venus, as dependent upon the smallness of normal velocity. After showing that the differences in time observations made on the transit of Mercury in November, 1868, actually amounted to

13 seconds, he remarks that, so far back as April, 1869, he pointed out the ratio of the probable errors arising from this cause in the transits of 1874 and 1882.

In a paper on the same subject, Mr. Proctor points out that from Mr. Stone's observations upon the transit of November, 1868, it can be shown how the discrepancy of 13 seconds can be reduced to one of only the tenth of a second.

Mr. Birt describes the spots and markings on the floor of the lunar crater Plato.

The Assistant-Secretary, Mr. Williams, has just completed the translation of the Chinese records of comets observed from B.C. 613 to A.D. 1640. Some of the observations will probably bear important fruit, since no well-authenticated accounts of comets, seen so long ago, exist elsewhere.

Mr. Browning supplies a most interesting paper on a change in the colour of the equatorial belt of Jupiter. During the month of October last he noticed that this belt, which is usually the brightest part of Jupiter's disc, exhibited a strong greenish yellow colour, and was darker than the bright belts north and south of it. Other observers, using Browning's reflecting telescopes, have observed similar appearances. Indeed, it is worthy of notice that, not only these changes of colour, but the colours ordinarily present in the discs of Jupiter and Saturn have been only seen distinctly with reflectors. MM. De la Rue and Lassell, for example, have seen these colours with their fine reflectors, whereas Dawes, with all his astonishing powers of vision, and though he used refractors of exquisite defining power, has not been able to recognize them clearly, if at all.

Mr. Weston supplies an interesting note on the lunar Apennine range and adjacent regions.

Mr. Carrington describes his new Observatory at Churt, Surrey. The principal telescope is an alt-azimuth, constructed on a new principle, the horizontal axis being the effective optical axis. A movable prism, placed outside the object-glass, reflects the object along the tube. Thus the telescope need never be raised, and the observer can remain always under cover.

Mr. Proctor puts forward a new theory of the Milky Way. He regards this sidereal group as forming a spiral of really small stars, swayed into its present position by the attractions of the large stars which are seen on the galaxy.

Messrs. Airy and Simms have at length brought their new eye-piece to its simplest and most perfect construction. By the mere rotation of the eye-glass—which must be plano-convex—all the effects of the flint-glass prisms described in our last Chronicle can be obtained without any mischief to the optical performance of the telescope.

Mr. Proctor supplies a paper on the application of photography

to determine the solar parallax from the transit of Venus in 1874. It is illustrated by fifteen pictures of the earth on her passage through the shadow-cone of Venus. The object of the paper is to show how photographs of the sun may be so taken, at different stations, that the relative displacement of Venus may be on a radius of the sun's disc.

In another paper he exhibits a method of constructing charts by which the great circle course between any two points on the globe may be accurately and quickly obtained.

Mr. Browning has invented a new form of micrometer for measuring the position of lines in faint spectra. By this arrangement an image of a bright cross is thrown on the spectrum, which it can be made to traverse by turning a micrometer screw. The advantages of the plan will be appreciated by those who know the difficulty of determining the position of the spectral lines by the usual arrangement.

4. BOTANY.

Influence of Climate and Soil upon Plants.—M. Kerner, of Innsbruck, has published a very interesting pamphlet on this subject, one of great importance in relation to the question of the origin of species. In the centre of distribution of a species, where it reaches its maximum of abundance, it is very unusual for varieties to become established; since, even if deviating forms were to appear, they would not be perpetuated, in consequence of the law of nature that cross-fertilization with other individuals, rather than self-fertilization, is the rule. On the outskirts, however, of the region of distribution, where the individuals are very scattered, a variation once appearing is likely to become established; because, the chances of self-fertilization being much greater, the peculiarities are likely to be perpetuated by heredity. Here therefore we must look for those aberrant forms which become the ancestors of new species. The author believes the direct influence of climate or soil in originating changes in the structure of plants to be extremely small; these changes being effected only in the course of many generations by the process of natural selection, those individuals which exhibit slight divergences suitable to the circumstances in which the plant is placed being most likely to survive, and to produce large numbers of seeds. Changed conditions of life can kill a plant, or destroy its health, but can have no direct influence in transforming it into a form more suitable for those conditions. As a contribution towards a series of observations on the relation between the flora of a country and its natural conditions of soil and climate, M. Kerner has paid special attention to the general features of the flora of the

Tyrolese Alps. Owing to the shortness of the period of activity of vegetation, which does not average more than from $1\frac{1}{2}$ to $3\frac{1}{2}$ months, few plants ripen their seeds before the return of constant frost. In consequence, while the proportion of annual plants is in the Mediterranean flora 42, and in that of the south-east of Europe 56 per cent., in the Alpine flora it is only 4 per cent. From the same circumstance the flower-buds of Alpine plants are commonly developed in the autumn before the return of frost, and burst into bloom immediately on the melting of the snow, before the appearance of the leaves. Another peculiarity of the Alpine vegetation is the very large number of plants with rosettes of stiff succulent or fleshy leaves, which both serve as reservoirs of food during the long winter, and are also proof against the sudden evaporation caused by the hot sun during the summer months. In contradistinction to this, is the almost entire absence of the bulbous plants which form so prominent a feature of the Mediterranean vegetation. Again, while the forests of tropical countries, where the summer is long and intense, abound with a luxuriance of climbing and creeping plants, these are almost entirely absent from the Alpine flora, where plants do not require to seek the shade.

Relation between the Distribution of Plants and of Animals.—Professor Delpino, of Florence, traces the gradual disappearance of many classes of plants as one proceeds northwards, to the absence of those animals, chiefly insects, which are necessary to effect their fertilization. In the Tropics many plants are fertilized by the agency of humming-birds, especially those possessing large trumpet-shaped flowers of a scarlet hue; and these are the first to disappear. Next follow those fertilized by the larger *Lepidoptera* and *Coleoptera*, as roses, peonies, the night-flowering *Sileneæ*, &c. In the Arctic zone those plants only can survive which are fertilized by *Hymenoptera* or *Diptera*, or by the wind; a few flies and midges, and a bee (*Bombus terrestris*) being the only insects found so far north as Nova Zembla. In the gardens near Florence are two species of *Lobelia*, one of which is abundantly visited by humble bees, and produces seed very freely; the other, notwithstanding its beauty and the abundance of its honey, is never visited by insects, and never bears seeds, but can easily be fertilized by artificial impregnation. Professor Delpino believes that in its native country it is fertilized by humming-birds.

Flora of Iceland.—Professor C. C. Babington read an interesting paper before the Linnean Society, January 20th, "On the Flora of Iceland." The most recent investigations have brought up the number of flowering plants indigenous to the island to about 450, of which all, with the exception of about sixty, are found also in Britain; all the remainder, with three exceptions, are natives of the European continent, chiefly of Scandinavia; there is no species of

flowering plants peculiar to the island. No woods are now to be found in the country, although some existed recently; the trees were all birch; nor is there any trace of the former existence of pines, or of any other kind of forest-tree; extensive woods of dwarf birch-trees are found in several parts, and some shrubby willows. No grain of any kind is grown on the island. The north-west corner, which has been comparatively little visited, appears to enjoy the least inhospitable climate.

Flora of Round Island, Mauritius.—At the meeting of the Linnean Society, held March 3rd, Dr. J. D. Hooker read a very interesting letter from Sir Henry Barkly, Governor of Mauritius, on the flora of this very little-known dependency of the colony. The island is about 25 miles from Port St. Louis, and only about 3 miles in circumference and 1¼ mile across; but its flora differs from that of the Mauritius, not only in species, but also in genera and even in families, although the depth of the intervening sea is only 400 feet. The island consists of a mound of tuff about 1000 feet in height, but without any apparent crater, bare of vegetation in the lower part. Only about twenty-four species of flowering plants were gathered during the visit, of which more than one-half are not found in the Mauritius, including three species of palm, one of them 30 or 40 feet high, a *Pandanus* or screw-pine, and two species of ebony. The fauna is equally peculiar.

Movements of Chlorophyll.—A very interesting series of observations has been made by the French botanists, Prillieux, Rose, and Brongniart, on the apparently spontaneous movements within the leaves of plants of the grains of chlorophyll which constitute the green colouring matter. These grains had been noticed by previous observers to congregate under the direct action of light. M. Prillieux performed his experiments on a species of moss, a kind of plant which offers great facility for these observations, as the movements can be observed in them under the microscope without dissection, owing to their transparency. When the moss had been kept in the dark for some days, the cells presented the appearance of a green network, between the meshes of which was a clear transparent ground. All the grains of chlorophyll were attached to the walls which separate the cells from one another; there were none on the upper or under walls which form the surfaces of the leaf. Under the influence of light the grains change their position from the lateral to the superficial walls, the movement taking place, under favourable circumstances, in about a quarter of an hour. On attaining their new position, the grains do not remain entirely immovable, but continually approach and separate from one another. If again darkened, they leave their new position, and return to the lateral walls. Artificial light produces the same effect as daylight. A protoplasmic material is intimately associated with the grains of

chlorophyll, causing them to move in masses of network rather than in isolated grains; and this protoplasm is supposed to be the vital and animating part of the cell.

Climbing Plants.—M. Paul Lévy sends from Nicaragua some interesting observations on climbing plants. Their vitality is something wonderful. M. Lévy tried many experiments upon them, and found that burning was almost the only effectual way of destroying them. If the stem is cut, they put out roots from their branches, and if these roots are cut off, they are reproduced even as many as eight times. This extraordinary vitality belongs, probably, only to the climbers of tropical countries, a large number of those observed by M. Lévy belonging to the genus *Bignonia.* Some species of climbers show a preference for particular trees on which to climb, refusing to attach themselves to some kinds, and clinging eagerly to others, in order to reach which they may have trailed for some distance along the ground. Some trees are always entirely destitute not only of climbers, but of mosses, ferns, orchids, and other epiphytes. All the climbers observed by M. Lévy turn from left to right, none from right to left, as has been stated by other observers.

Alternation of Generation in Fungi.—Some remarkable observations on this subject have recently been made by M. Gabriel Rivet. It was noticed as long since as 1806 by Sir Joseph Banks, that the proximity of the Berberry-tree appears to be a cause of the prevalence of the disease known as "rust" in the grain-crops of the neighbourhood. It has now been ascertained that one of the Fungi which produce the rust in cereals, the *Puccinia graminis*, and the Fungus which causes the well-known orange spots on the leaves of the Berberry, the *Œcidium Berberidis*, are in reality different forms of the same plant; the spores of each form will not reproduce itself, but the other form. In the commune of Genlis, department of Côte-d'Or, in France, a railway company has recently planted its embankments with Berberry-trees, and immediately afterwards the crops of wheat, rye, and barley in the neighbourhood became infested with rust. A commission being appointed to investigate the subject, reported that wherever the Berberries are found the grain-crops are more or less attacked by rust; where they do not occur the crops are free, and that the planting of a single bush of Berberry is sufficient to produce the disease where it has never appeared before.

Variegation of Leaves.—M. Edouard Morren reports some important observations on the variegation of leaves, which he attributes to a kind of disease, capable of being inoculated from one individual to another, and even to a different species. By grafting a variegated plant on another, the infection can be conveyed downwards, no doubt by the circulation of the sap, and can even be carried upwards from a variegated stock to a healthy plant grafted upon it. M. Morren states that the placing of a variegated leaf beneath the bark

of a branch of a healthy plant is even sufficient to produce the disease. Variegation may be produced by various causes, debility in the seed, dampness of the ground, want of light, &c. It can be propagated by layers, buds, or grafts, but not, under ordinary circumstances, by seeds. Variegation is partial decoloration or want of strength to produce the green grains of chlorophyll; if the decoloration is general, it causes death. None of the higher plants, except a few which are parasitic, can exist if entirely deprived of chlorophyll; though a perfectly blanched branch may occasionally lead a parasitic life on the remainder of the plant.

Cultivation of Cinchona.—Many climates are now found to be adapted to the profitable growth of the *Cinchona*, or Peruvian bark. In addition to its introduction into St. Helena, reported some time since, it is now grown on a small scale in the Azores. In our own governments of Madras and Bengal its cultivation is rapidly extending. From a report recently published by Mr. C. B. Clarke, Assistant-Superintendent of the Botanic Garden at Calcutta, it appears that the increase in the number of plants at the Darjeeling plantations during the year ending March 31st, 1869, was 673,654, making in all over three million plants, belonging to the three species *Cinchona officinalis*, *succirubra*, and *micrantha*, the area covered on the 1st of April, 1869, being 965 acres. There is also a smaller Government plantation at Nunklow, in the Khasia Hills. The tallest plants grown at Darjeeling are 19 feet high. Mr. Broughton, chemist to the Cinchona plantations in the Madras Presidency, believes that all the sub-varieties are permanent, and have been produced by artificial hybridization; but that hybridization seldom takes place in nature.

The Chair of Botany at the College of Science, Dublin.—This appointment, vacant by the resignation of Professor Wyville Thomson, has been conferred on Mr. W. T. Dyer, author of 'A Flora of Middlesex.' A vacancy is thus occasioned in the Professorship of Natural History in the Royal Agricultural College at Cirencester.

5. CHEMISTRY.

A VERY unexpected fact has been published by Professor Wanklyn. It has usually been considered that the affinity of chlorine for the alkali metals was very energetic, and when it is remembered that antimony and arsenic burst into flame when introduced into this gas, it was reasonable to suppose that the reaction between chlorine and sodium would be even more violent. Mr. Wanklyn, however, has shown that when chlorine gas is passed over metallic sodium—even when the metal is fused, and, whilst in a state of fusion, shaken

in contact with the gas, so as to expose the fresh metallic surface—there is no action. A glass vessel containing a piece of sodium was weighed, and after the transmission of chlorine, under the circumstances above named, it was re-weighed, and found to be practically the same.

Mr. H. C. Sorby has published a detailed account of some remarkable spectra of compounds of zirconia and the oxides of uranium. The phenomena which he has observed are very complicated, and reflect the highest honour on his philosophical acumen. Some of the peculiarities in the spectra of compounds of the oxide of uranium with zirconia, led Mr. Sorby and others, some time back, to conclude that they were due to a new elementary substance.

A rapid method for the quantitative estimation of sulphur in cast-iron and steel is a great desideratum in metallurgical laboratories. Mr. Eggertz has described a process, based upon the shade of coloration which small quantities of sulphuretted hydrogen produce upon pure silver, or certain alloys thereof. In a glass-stoppered bottle, a mixture is poured of water and sulphuric acid, to which is added the metal, reduced to the finest possible powder. There is then suspended, by means of a very fine platinum wire, in the bottle, without touching the fluid, a clean piece of metallic silver, the platinum wire being held squeezed between the stopper and the neck of the bottle. The metal dissolves, in a moderately warm room, within a quarter of an hour, so that the silver can be taken out and examined after that time. The author has, by means of a series of experiments, been enabled to construct a scale of numbers representing, according to certain shades of coloration, the quantities of sulphur found.

Naphthaline is a waste product occurring in large quantities in gas works. The problem is how to utilize it. Dr. Ott has examined its properties with this object. Pure naphthaline is similar in appearance to alabaster, cracks easily in the warm hands, and becomes negatively electric on being rubbed with silk. It melts at 174° F., and boils at 452° F. Molten naphthaline absorbs a large quantity of air, which is given off again on cooling; according to M. Vohl, this gas is pure oxygen. Molten naphthaline dissolves indigo with great facility, forming a dark-blue violet liquid, from which the indigo separates on cooling, forming fine shining needles like copper. The amorphous sulphides of arsenic, tin, and antimony are also readily dissolved, and likewise phosphorus, sulphur, iodine, the iodide and chloride of mercury, arsenious, succinic, benzoic, and oxalic acids. Professor Asa Gray has thoroughly tested and obtained satisfactory results, proving that naphthaline may be advantageously used in museums, herbariums, &c., instead of camphor, as a very effective protection against moths and other insects.

It appears that in the utilization of the cane sugar existing in Madder-root, there is a fair field of profitable experimental research still left open and untouched. Madder-root, and especially the Zealand madder, is rich in cane sugar, containing between 14 and 16 per cent. The extraction of this sugar, without interfering with the tinctorial value of madder, and by means different from those whereby that sugar is now utilized—*viz.* fermentation and making of alcohol—is a problem still to be solved. Some 10,000,000 kilos. of madder are, at the very lowest estimate, consumed annually, and the bulk of the sugar therein contained is utterly lost.

We have received, from Mr. H. N. Draper, a pamphlet, from which we learn that the use of methylated ether as an intoxicant, instead of alcohol, is very general in the counties of Londonderry, Antrim, and Tyrone. The quantity taken at one time is from two to four drachms, and the dose is repeated twice, thrice, or even four and six times daily. Mr. Draper treats the subject in its relation to the inland revenue, and also to insurance companies, the former suffering by the practice to the extent of 5666*l.* per annum, while the risks of the latter are increased by such an inflammable liquid being stored and handled by people ignorant of its properties.

As a new disinfectant M. Paquet proposes the use of thymol, the stearopten of the essential oil from *Ptychotis ajowan*, an umbelliferous plant growing in India. In the undiluted state, this substance is a caustic, and is used in dentistry for the cauterization of hollow teeth; its advantage in this respect being that it has not an unpleasant taste, and, being very aromatic, does not affect the breath as carbolic acid does. Its aqueous solution is a strong antiseptic, and possesses disinfectant properties in a very high degree.

MM. Sepulchre and Ohressir have perfectly succeeded in utilizing the slag of the iron blast furnaces for the manufacture of paving stones, which withstand a crushing weight of more than 400 kilos. per square centim., and have answered for the purpose of paving several streets at Brussels and Paris, and stood heavy traffic, far better than even the celebrated Quenast stones. The streets paved with this material at Brussels have a heavy gradient.

The fatty matter contained in sheep's wool, technically known as snint, is likely to become of considerable commercial importance. It contains some 40 per cent. of potassa; and when ignited this alkali becomes thereby intimately mixed with strongly-nitrogenized animal charcoal. M. Havrez points out the profit to be derived from the use of snint for the manufacture of prussiates and cyanides, and M. Schattenmann, prussiate and cyanide manufacturer at Bouxwillir, near Strasburg, states that results of experiments made with snint by him on large scale, are decidedly favourable to the use of

that substance for the purpose alluded to. It should be observed that the quantity of snint contained in raw wool amounts to one-third of its weight; and that in 1867 there were imported into the United Kingdom 63,000,000 kilos. of raw wool from the Cape and Australia, the quantity of snint contained therein amounting to at least 20,000,000 kilos.

The use of hypophosphoric acid in agriculture for the purpose of destroying noxious insects has been proposed by M. Martin, for the destruction of the *Phylloxera-vastatrix*, which makes great havoc in the vineyards. The makers of phosphorus obtain a quantity of this acid in aqueous solution, which is thrown away as waste; but since the transport of this waste liquid is too costly (it may be very usefully applied where it can be had with ease), the author describes a method of making hypophosphoric acid by the slow combustion of phosphorus. According to his experiments, 2 grammes of this acid dissolved in 10 or 12 litres of water, is a strong poison for all kinds of insects, and not only does not hurt plants, but actually does good by increasing the soluble phosphates in the soil.

The solution of oxide of copper in ammonia acts as an energetic solvent upon cellulose; this property is made use of by A. Jouglet to waterproof paper in the following manner:—A tank is made to contain the solution just alluded to, and the paper is rapidly passed just over and in contact with the surface of the liquid, by means of properly-placed rollers moving with speed. The paper, on leaving, is pressed between two cylinders, and next dried by means of so-called drying cylinders, similar to those in use in paper-mills. The short contact of the felty paper-tissue with the liquid gives rise to just sufficient solution of cellulose to form an impermeable varnish.

A process for the preservation of butchers' meat, invented by M. Georges, is now in use on the large scale at Monte Video. The meat, in pieces weighing from 2 to 50 kilos., is placed in a mixture of water, hydrochloric acid, glycerine, and bisulphite of soda. After having been steeped for some time, the pieces are taken out and dusted over with finely-powdered dry bisulphite of soda, and then packed in air-tight boxes, filled as full as possible. In this state the meat keeps fresh any length of time, and becomes perfectly fit for use—equal to fresh butchers' meat—by steeping for a short time in water to which vinegar has been added, and afterwards exposure to air; the price of the preserved meat, of which it would be easy to supply to London and to Paris daily over 10 tons, is from 50 to 60 centimes per kilo.

Hydrate of chloral, the new anæsthetic and sedative, is daily increasing in importance, and many processes have been given for

its preparation: the best is probably that of MM. Müller and Paul. Their process consists in passing a current of dry and pure chlorine gas into pure and absolute alcohol, until the contents of the flask are, after about seventy hours, converted into a white and crystalline mass; when this operation is properly conducted, a large quantity of hydrate of chloral is obtained. Hydrate of chloral is readily sublimed, and may be thus obtained as a dry, snow-white, neutral crystalline powder. It does not exhibit any smell at the ordinary temperature of the air; it volatilizes slowly, without absorbing much moisture, unless it be placed in a very damp place; it fuses at 56°, boils at 145°, is completely soluble in a small quantity of water, and also soluble in alcohol, ether, chloroform, sulphide of carbon, benzol, and fatty substances. Its aqueous solution ought to be neutral to test-paper, and should not become turbid by a solution of nitrate of silver.

It is now proposed to make the reflecting surfaces of looking-glasses of platinum instead of tin amalgam or silver. M. Jouglet prepares the platinizing compound in the following manner:—Very thin platinum foil is dissolved in aqua regia, the solution carefully evaporated to dryness, the solid chloride next placed on a triturating marble, and gradually mixed with essential oil of lavender. When incorporated with the chloride, the mixture is placed in a porcelain capsule, and left standing for several days; the fluid is decanted from any sediment, and filtered. As flux for 100 grains of platinum the following ingredients are used:—25 grains of litharge and 25 grains of borate of lead, mixed and triturated together with about 10 grains of essence of lavender; this is next mixed with the platinizing fluid. After a layer of platinum has been formed upon the glass, it is fixed by burning it in by placing the glass in peculiarly-constructed muffles.

From a series of observations made at Monaco, on the shores of the Mediterranean, Dr. Gillebert d'Hercourt concludes that there is always on the sea-shore an atmosphere impregnated with saline particles; this layer of air has, at the above-named place, some 500 metres horizontal and 60 metres vertical extent. This impregnation of salt is due to what the author terms "pulverization" of the sea-water by the breaking up of the surf, and is not directly influenced either by barometric pressure, hygrometric state of the atmosphere, or temperature. This hydro-mineral dust, as it is called by the author, is, unless there happen to exist near the coast physical obstacles in the shape of high mountains, carried far away inland, and is not to be confounded with what is of more coarse nature, and termed "spray," which is only quite local and produced when a gale of wind blows. The author states that, even on calm days in winter, the atmosphere near Monaco is up to a height of 70

metres, and some few miles inland, impregnated with this hydro-mineral dust.

As a proof of the greatly-improved mode of manufacture of sulphide of carbon and its very extensive use, M. Contet states that in 1840 the kilo. of rectified sulphide of carbon cost 50 francs (2*l*.). In 1848 M. Deiss manufactured it, and sold it at 8 francs per kilo.; and now it may be had wholesale at 50 centimes the same quantity. As regards the purification, M. Sidot first re-distils the raw product, then shakes the distillate up with mercury until the latter becomes black, and this operation is so long repeated as the metal is affected by the fluid, or rather by any sulphur dissolved in it. Sulphide of carbon thus purified is freed from the fœtid odour it generally has, and exhibits a smell of ether. M. Cloeg renders commercial sulphide of carbon inodorous by leaving it for twenty-four hours in contact with half per cent. of its weight of finely-powdered corrosive sublimate, care being taken to shake or stir up this mixture. The mercurial compound combines with the substances which are the cause of the fœtid odour of this substance, and an insoluble compound is deposited. The liquid is carefully decanted, and after a little pure inodorous fat has been added, the sulphide is re-distilled by the heat of a water-bath. The sulphide thus obtained exhibits an ethereal odour, and is eminently suitable for the extraction of oils, fats, &c., from various substances, since on evaporation of the purified sulphide these matters are obtained in as fresh and pure a state as if the oils had been obtained by pressure.

M. Coupier has succeeded in obtaining fuchsine without the use of arsenic by the action of hydrochloric acid and iron, in small quantities, upon pure aniline and nitro-toluol, taking care to apply a suitable temperature. Commercial aniline and commercial nitro-benzol also yield the same result; and M. Schützenberger states that having been requested to test the results of this reaction, he has found that the aniline red obtained is identical with that ordinarily made, and declared it to be a salt of rosaniline. The yield is very fair, and somewhat larger than when arsenic is used.

A lengthy memoir on various processes for preserving timber has been published by Dr. Ott. From it we learn that the opinion that carbolic acid and substances containing it are effectual in preserving timber is erroneous. The real preservative action of the tar-oils is due, according to this author, to a greenish fluorescent oil that comes over at the last stage of the distillation. Direct trials with pyren and paranaphthaline do not yield successful results. The question whether tar (coal-tar) contains a sufficient quantity of the fluorescent greenish oil just alluded to, to justify the use of coal-tar for preservative purposes, is answered in the negative. The decay of timber, or peculiar transformation which makes it unfit for

practical purposes, seems to be, in most instances, produced by the attack of fungi and lichens. The mouldering of wood is distinct from decay, it being merely a chemical process caused by the action of water with small access of air. None of the processes invented to preserve timber by chemicals are perfect. The most simple and practical method is the old, but, unfortunately, far too slow plan of properly subjecting timber to the action of air and water, as practised in ship-building yards. *A propos* of the method of preserving wood by impregnation with sulphate of copper, it may be interesting to know that by an order recently issued by M. le Maire de Douai, the bakers of that town have been prohibited from using the wood of old railway sleepers as fuel for their ovens, since many of these sleepers have been impregnated with sulphate of copper, and there is danger that some compound of copper might poison the bread.

Professor Morton has described the works at New York where oxygen gas is manufactured on the large scale. The works consist of retort-houses, engine-rooms, store-house, pumps for compressing gas in cylinders, and a gas-holder of 26,000 cubic feet capacity. The process is carried on as follows:—About 700 lbs. of manganate of soda are placed in the retort, and heated to the requisite degree; superheated steam from a boiler is then admitted for about ten minutes. Two equivalents of the manganate of soda and two of water react upon each other, the water combines with the soda of the manganate to form a hydrate of soda, the manganic acid is converted into sesquioxide of manganese, containing only half the proportion of oxygen, and the other half of the oxygen passes off in the free state. At the conclusion of this part of the process the steam is shut off, and the superheated air is admitted for about fifteen minutes, whereupon the sesquioxide combines with more oxygen from the air, and is re-converted into manganic acid, which again combines with soda. The retorts in each furnace are charged with 700 lbs. of permanganate of soda, and by the consumption of 2 chaldrons of coke, and with the labour of three men, 25,000 cubic feet of oxygen are made per day. It is now sold at $2\frac{1}{2}d.$ per cubic foot, compressed in reservoirs up to a pressure of 250 lbs. to the square inch. The gas is of excellent quality, and very pure.

6. ENGINEERING—CIVIL AND MECHANICAL.

Light Railways.—The great question of the day amongst engineers, at the present time, is the construction of light, or narrow-gauge railways. The enormous expense which has attended the laying-down of existing lines upon what is styled the "standard" gauge, and their comparative unremunerativeness, have naturally led to the consideration of how the existing want of increased facilities of communication can best be supplied so as to recommend new projects for railway extension to the confidence of capitalists and the public generally. The subject has also obtained increased prominence in consequence of the arrival of a Russian Commission to investigate the means of communication in this country, and who, together with many other foreigners of distinction, and leading English engineers and others, paid a visit last February to the little Festiniog Railway in North Wales. As this line has the narrowest gauge of any existing railway worked by locomotive power, some description of it here may not be inappropriate.

Festiniog Railway.—This line, which is 13¼ miles in length, extends from Portmadoc to the slate quarries in the neighbourhood of Festiniog. It is slightly under 2 feet in width of gauge, and was originally constructed for horse traction, by which power it was worked until 1863, when the increased traffic necessitated the employment of steam power for that purpose. The line was strengthened and improved, diminutive locomotives were constructed expressly for it, and since 1865 passenger carriages have been attached to each train. The difference in level between the two termini is 700 feet, and the average gradient is 1 in 92. The steepest gradient on the portion now used for passengers is 1 in 79·82, and the steepest on which locomotive engines are employed, 1 in 60. Some of the curves are exceedingly sharp, having radii varying from 2 chains to 4 chains. As the line is a continuous incline from Portmadoc to Festiniog, the locomotive is employed only to draw the trains in one direction; it then returns by itself, and the loaded trains run by gravitation down to Portmadoc—their speed being regulated by breaks. The original capital of the company was 36,000*l.* Since that outlay was incurred the line has been almost reconstructed; workshops have been erected and rolling stock manufactured out of revenue, bringing up the total cost of the line to about 86,000*l.* The net profits have amounted to upwards of 30 per cent. on the original capital, and they exceed 12½ per cent. on the total outlay of the undertaking.

New Tunnel under the Thames.—The past quarter has witnessed the completion of a tunnel under the river Thames between Tower Hill and Vine Street, Tooley Street. The noticeable feature

of this work is the extreme rapidity, and comparatively trifling cost at which it has been constructed, the time occupied being only one year, and the total expense less than 20,000*l.*, whereas the old Thames Tunnel occupied eighteen years in construction, and cost over half-a-million sterling. This new tunnel consists of a circular driftway, 7 feet 3 inches in diameter, having an inclination from either side towards the centre of the river of 1 in 30. It is approached on each bank by a perpendicular shaft, that on the Middlesex side being 56 feet deep, and that on the Surrey side 52 feet. The lift at either end consists of an iron chamber, to the roof of which a chain is attached, which passes over a pulley at the head of the shaft, and at the other end is fixed to a balance weight, capable of adjustment according to the number of passengers in the lift. The bottom of each shaft communicates with a waiting-room, having seats along the sides. Along the tunnel is laid a railway of 2 feet 6 inches gauge, on which a small omnibus runs, capable of accommodating fourteen passengers at one time. Under the level of the tunnel at the bottom of each shaft there is an engine-room containing a 4-horse power engine for raising and lowering the lifts, and that on the Surrey side is also employed for hauling the omnibus, which is driven by means of an endless steel cord passing round a vertical pulley-wheel at the Surrey end of the tunnel, and a horizontal pulley-wheel placed between the rails at the Middlesex end.

Proceedings of Societies.

Institution of Civil Engineers.—The session of 1870 was inaugurated on the 11th January by an address from the newly-elected President, Mr. Charles Blacker Vignoles, F.R.S. It would be impossible briefly to summarize Mr. Vignoles' speech, which for interest and importance has never been surpassed, and rarely equalled. In reading over this important paper, it appears that no branch of the profession has escaped notice from the time when "in the earlier stages of the human race their first want must have been, as it is now, a supply of water for men and beasts of tribes, whether nomadic or stationary, when no longer within reach of the natural streams or springs; and assuredly," said Mr. Vignoles, "the individual who first dug a well in the desert, and raised water to the surface, by the simple contrivance of pole and bucket, was the first mechanic—the first pre-historic engineer, whose rude invention has nevertheless been followed in all subsequent ages," down to the completion of the Suez Canal, "by cutting across the sandy ligament which has hitherto united Asia and Africa, by which a water communication has been opened, which will never again be closed so long as mercantile prosperity lasts or civilization exists."

"On the Statistics of Railway Expenditure and Income, and their Bearing on Future Railway Policy and Management." A paper on this subject was read before the Institution on 1st February last, by Mr. John Thornhill Harrison. After referring to the income from passengers and goods on the principal lines in the kingdom, the question of the further extension of railways was considered, and it was urged that many lines might be constructed at a cost of from 3000*l.* to 5000*l.* per mile, provided the landowners would sell their land for the purpose at the ordinary market value; that the Board of Trade would allow level crossings, and that gradients as steep as 1 in 20 or 1 in 30 were adopted. The subject of expenditure for working the line was next dwelt upon in some detail, and the percentage of net revenue on the total capital expended. Two large funds for investment of capital were also considered: the National Debt, which amounted to 750 millions sterling, and gave a return of 26½ millions per annum, or 3½ per cent., which was a burden on the industry and capital of the country; and the capital expended on railways, which amounted to 500 millions sterling, giving a return of 20 millions, or 4 per cent. per annum; whilst a sum nearly equal to the interest on the National Debt was annually expended in labour and materials.

Society of Engineers.—On 7th February Mr. William Adams, the newly-elected President, inaugurated the session of 1870–71 by an address. After reviewing the progress of the Society, and adverting to the several papers read during the preceding session, he proceeded to make some remarks upon locomotive engineering and the rolling stock of railways, detailing the several improvements that have of late years been introduced, and especially with reference to the application of break-power for bringing trains to a standstill, the two most important improvements for that purpose being the steam-break of M. Le Chatelier, and the friction-wheel break of Mr. John Clark.

South Wales Institute of Engineers.—An important paper has recently been read by Mr. Brogden, before the South Wales Institute of Engineers, "On the Comparative Merits of Large and Small Trams or Wagons for Colliery use." In the course of the discussion that followed it transpired that at a colliery in the Aberdare Valley there had been effected by the introduction of small trams a saving of 1*s.* 3*d.* per ton. In getting out 150 tons a day with a large tram fourteen horses were employed at a cost of 4*l.* 12*s.* 8*d.*, whilst with small trams the same amount of work was done for 1*l.* 11*s.* 8*d.*, showing a saving of nearly 6*d.* a ton on that item alone; besides which there was a difference in the price of driving headways, in the cost of rails, sleepers, &c. By the use of small trams there was also a considerable saving in the men called "dusters," and by reducing the headway a saving in "gobbers."

Men, it was also said, could earn more by the use of the small tram, which is therefore advantageous to them as well as to the masters.

Civil and Mechanical Engineers' Society.—On 8th December last Mr. R. M. Bancroft read a paper before this Society "On the Renewal of King's Cross Station Roof." When this station was opened in 1852 its roof created some little sensation, as it was the largest span-roof of the laminated type constructed in this country. After a period of eighteen years' existence it was found that the timber which formed the ribs was in a state of rapid decay, and it became necessary to replace them with something more durable. The wrought-iron main ribs were formed and accurately curved so as to fit in exactly between the old cast-iron shoes built in the walls on each side, the cast-iron spandril fillings of the old roof being cut shorter to suit the new wrought-iron ribs. The scaffold for the construction of the roof was designed so as not to interfere with the traffic constantly passing beneath it, and the large wrought-iron plate-girders forming it were constructed of such section that they might hereafter be used in bridges down the line.

Institution of Engineers in Scotland.—Professor W. J. Macquorn Rankine read a very interesting paper before this Society, upon being called upon to fill the presidential chair until the next election. This paper partook of the nature of a presidential address, and consisted of a review of the present state of engineering *progress* in its various and numerous branches; but it is on the subject of "Engineering Education" that Professor Rankine's paper dwelt with most force. In alluding to common errors under existing systems of education, the Professor stated: "One is led to expect results from the scientific branch of education which it is not really capable of accomplishing. The purely practical parts of engineering, such as the use of tools and the superintendence of works, cannot be soundly and thoroughly learned except through experience in real business; and it is a mistake to endeavour to teach them during a university course. The true laboratory for students of engineering science is to be found in the workshops of such cities as Glasgow, and amongst the earthwork, masonry, carpentry, and ironwork of engineering structures in progress."

Institution of Mechanical Engineers.—At the anniversary meeting of this Institution on the 27th January last, a paper "On Le Chatelier's Plan of using Counter-pressure Steam as a Brake in Locomotive Engines," by Mr. C. W. Siemens, came under discussion; and a paper was read by Mr. C. Cochrane, of Dudley, "On the further Economy of Fuel in Blast Furnaces, derivable from the High Temperature of Blast obtained with Cowper's Improved Regenerative Stoves at Ormesby, and from increased Capacity of Furnace, &c." M. Le Chatelier's plan for counter-pressure working

consists in introducing a small jet of hot water from the boiler into the base of the blast-pipe or the exhaust part of the cylinder: this jet being discharged at boiler pressure into the atmospheric pressure of the exhaust passages, the greater portion of the water instantly flashes into steam at atmospheric pressure, and instead of the heated gases from the smoke-box, a moist vapour or fog is now drawn into the cylinder behind the piston, upon the engine being reversed.

Literature.

"Our Iron-clad Ships; their Qualities, Performances, and Cost; with Chapters on Turret Ships, Iron-clad Rams, &c." By E. J. Reed, C.B., Chief Constructor of the Navy, &c.* Space will not admit of such a review here as this work deserves. The fact of its coming from the pen of one so experienced in the subject will at once commend it as an authority upon the matter of which it treats. Its title will convey a fair idea of the contents of the 320 pages of which this book consists; and we can only here state that whilst this treatise on Iron-clad Ships evinces a masterly knowledge of the subject on the part of its author, the style in which it is written is perfect, approaching at times to eloquence.

7. GEOLOGY AND PALÆONTOLOGY.

(Including the Proceedings of the Geological Society and Notices of recent Geological Works.)

Monographs of the Palæontographical Society, Vol. XXIII.—The success attending combined efforts was never more happily illustrated than in the case of the Palæontographical Society, which was formed twenty-three years ago for the purpose of describing and figuring British Fossils. It has published the works of twenty-six palæontologists, embracing in their monographs every division of the animal kingdom found fossil in this country. Nor is it merely the letter-press descriptions of fossils which it effects (though these now amount to 6405 pages 4to), but it is the superior means of illustration it furnishes which gives such value to the volumes of this Society. The plates now number 1006, and contain 18,991 figures. The volume before us contains 43 plates, some of which are double size. These plates, with descriptive text, are distributed to subscribers for 1*l*. 1*s*. per annum.

The volumes of the Palæontographical always contain a diverse series of monographs; thus we have in this year's issue,—Fossil

* John Murray. London: 1869.

Corals, Cretaceous Echinoderms, Oxford Clay Belemnites, Old Red Sandstone Fishes, Lias Pterodactyles, and Crag Cetacea. Such a "bill of fare" was never before presented at so modest a price.

Dr. Duncan's part contains six species of Corals from the Greensand of Haldon, thirteen species from the Gault, and six from the Lower Greensand. To this part is appended a complete list of British Cretaceous Corals, fifty-eight in all.

Dr. Duncan remarks, "The Coral-fauna of the British area was by no means well-developed or rich in genera during the long period in which the Cretaceous sediments were being deposited. The Coral tracts of the early part of the period were on the areas now occupied by the Alpine Neocomian strata, and those of the middle portion of the period were where the Lower Chalk is developed at Gosau, Uchaux, and Martigues."

"There are no traces of any Coral-reefs or atolls in the British Cretaceous area, and its corals were of a kind whose representatives for the most part live at a depth of from 5 to 600 fathoms."*

In Professor Phillips's monograph on the Oxford Clay Belemnites, the author notices a singular hiatus between the Inferior Oolite and the Oxfordian stage. It must, however, be borne in mind that pelagic and freely-wandering animals (such as the *Belemnitidæ* must have been, judging from their modern representatives, the Squids, Calamaries, and Cuttle-fishes) form a less sure basis for generalization than do the Brachiopoda and other sedentary forms of *Mollusca* and the Corals.

Free swimming Cephalopoda might forsake a large area for ages, if conditions were unfavourable, returning again at a later epoch, and again becoming plentiful as fossil remains in the mud of the period.

It is interesting to observe that Professor Phillips, who is perhaps the most careful observer living, and the last man to be carried away by an idea, has adopted the doctrine of descent with modifications, as may be gathered from the following extract;† speaking of *Belemnites explanatus*, sp. nov., from the Kimmeridge Clay, Professor Phillips observes, "On many accounts this form of Belemnite is of interest in the study of the series to which it belongs. On the one hand its resemblance to the older type of *B. abbreviatus* (*excentricus*) of the Oxford Clay and Oolite, and on the other to that of Speeton, in Yorkshire (*B. lateralis*), is such as to offer a most instructive example for study, in relation to the derivation of successive specific forms by hereditary transmission with modification."

Some interesting modern types of Loricarian fishes illustrate Mr. Ray Lankester's monograph on the *Cephalaspidæ* of the Old Red Sandstone.

* P. 46. † P. 128.

These curious buckler-headed fishes are certainly among the most interesting as they are undoubtedly the very earliest forms of the vertebrate type with which we are acquainted.

One head-shield figured measures more than 6 inches across and above 7 inches in length.

Mr. Fielding has most successfully rendered the fine and delicate striæ on the plates of *Pteraspis* in plates vi. and vii. The histology of these fish-plates is carefully worked out and most beautifully illustrated by Tuffen West.

Professor Owen's monograph on the Lias *Pterosauria* deserves more than a passing notice.

For the first time we see before us an entire British Pterodactyle in his *Dimorphodon macronyx*, not restored at random, but carefully put together bone by bone from the three specimens in the British Museum. *Dimorphodon*, as we thus know it, has a long and slender tail firmly set and imbedded in ossified tendons, rendering it apparently an inflexible rudder; the hind limbs are well developed, as also are the claws and the wing-fingers. The head is very large, with beautiful contrivances for lightening it by means of large vacuities; the jaws are armed with larger laniary teeth, and rows of more regular minute and pointed teeth. There is no evidence that this species had a beak or horny termination to its jaws as Von Meyer believes to have been the case in *Rhamphorhynchus* from the Solenhofen beds.

Upon the affinities of the *Pterosauria* Professor Owen is at issue with Professor Huxley, the former arguing against their Ornithic and in favour of their Reptilian affinities, the latter placing them in the same group with the *Dinosauria*, the *Crocodilia*, and the *Anomodontia* (called by Professor Huxley the *Ornithoscelida*), the most bird-like of the Reptilia.

Professor Owen argues that the possession of feathers and warm blood are essentially bird-like attributes, whilst the absence of feathers in the *Pterosauria* proves them to have been cold-blooded reptiles. The Cockchafer is cited by Professor Owen to prove that powerful flight may co-exist with cold blood; but if we could compare the bulk of the insect with that of the Pterodactyle, there seems little doubt that the temperature would also increase with the size of the animal, and in proportion to the increased muscular work required to be accomplished.

We deprecate the tone adopted by the author in his critical review of Professor Huxley's observations,* and earnestly hope it may not be found in any future monographs.

The concluding Monograph, also by Professor Owen, treats of the Cetacean remains, occurring in the Red Crag, belonging to the genus *Ziphius* of Cuvier. These curious rostra are found in tole-

* P. 74.

rable abundance in the Coprolite-workings in the Red Crag of Suffolk, and are usually much water-worn and eroded, as if the bed in which they were originally deposited had undergone subsequent denudation on some later Tertiary sea-beach. They often appear to have been bored into by *Pholades*.

Twenty-three articles appear in the last three numbers of the 'Geological Magazine.' Of these the most important are: "On the Sequence of the Glacial Beds," by Searles V. Wood, jun.; "On Lithodomous Perforations," by J. Rofe, F.G.S.; "The Millstone Grit of the North Wales Border," by D. C. Davies; "The Character of Lavas," by G. Poulett Scrope, F.R.S.; "On Faults in Strata," by W. T. Blanford and by G. H. Kinahan; "New Zealand Plesiosaurs," by Professor Owen; "Boulder-Clay," by Mr. James Geikie; "Banded and Brecciated Concretions," by Dr. Ruskin. If Mr. Searles Wood, jun., can only induce the Geological Survey to adopt his classification for the later deposits of our island, much of our misery and uncertainty about the Contorted Drift and Boulder-Clay ends, and we may find a place for every pebble-bed and drift-deposit which we meet with, and can colour it at once.

But the Geological Survey are not converted, although they will, doubtless, gladly adopt much of Mr. S. V. Wood, jun.'s, admirable work on East Anglian surface-geology, when they come to Norfolk, Suffolk, and Essex.

Mr. Scrope continues his favourite theme, the character of Lavas. We hear, by-the-by, that he is arranging with Mr. Archibald Geikie a descent upon the Lipari Islands and Stromboli this summer, so we may look for a new view of modern volcanoes from a leading man of the day in Geology.

Proceedings of the Geological Society of London.

The present number of the 'Quarterly Journal' of this Society deals in Australian Geology and Palæontology. On Dinosaurian Reptiles and their affinity with Birds. The evidence afforded by corals as to the physical geography of Western Europe in Secondary and Tertiary times. The Brachiopoda of the Budleigh-Salterton pebble-bed. A comparison of the Boulder-clay of the North of England with that of the South. On the Graphite of the Laurentian of Canada. On the Geology of the country around the Gulf of Cambay. On the Rodents of the Somersetshire Caves.

With rocks of Secondary age in Australia we have been hitherto unacquainted, and there seemed good reason to believe that this remarkable country held its head above water through the Mesozoic period.

Mr. Charles Moore has, however, brought before us evidence of

the occurrence of fossils in erratic blocks from Western Australia, from the centre of the Continent, on Stuart's route, and from Queensland. These remains, although fragmentary, suffice to indicate fossils of Liassic, Oolitic, and Neocomian age.

The propriety, however, of applying the European palæontological standard to the geology of the Antipodes is exceedingly doubtful, and we are more than ever impressed with the value of the late Edward Forbes's observation, that the occurrence of similar fossils in formations of widely-separated continents was rather a proof of the diversity of their age than of their synchronous character. That marine faunas extend over a far wider geographical area than land animals must be admitted, but Mr. Seeley's observation, that natural groups of corresponding value exist in different areas of the globe, deserves consideration.

Professor Huxley contributes three papers, all bearing upon the Dinosauria and their affinity with Birds.

The skeleton of a young Iguanodon from the Wealden of the Isle of Wight (described long since by Professor Owen) proves, upon further examination, to be a new genus of Herbivorous Dinosaur (*Hypsilophodon Foxii*), and assists largely to increase the evidence in favour of the affinity between Dinosaurian Reptiles and Birds. A head of *Hypsilophodon* (obtained by the Rev. W. Fox), and referred to the same species, seems to have had its præmaxillaries produced downwards and forwards into a short edentulous beak-like process, the outer surface of which is rugose and pitted. The peculiar form of the lower jaw of Iguanodon would seem to indicate that its emargination was destined to receive this beak-like process of the præmaxillaries. The pelvic bones are singularly avian in their structure.

Professor Huxley reviews in his second paper the evidence already cited by himself and others (especially by Professor E. D. Cope, of Philadelphia), in favour of the ornithic affinities presented by the Dinosauria, and discusses at length the recently ascertained facts which bear upon this question. He compared the different elements of the pelvic arch and hind limbs in the Crocodile, the Dinosaur, and the Emu, and maintained that the structure of the pelvic bones (especially the form and position of the ischium and pubis), the relation between the distal end of the tibia and the astragalus (which is perfectly ornithic), and the strong enemial crest of the tibia, &c., furnish additional and important evidence of the affinities between the Dinosauria and Birds.

In Professor Huxley's third paper he referred to the bibliography of the Dinosauria, which, as a distinct group, were first recognized by Hermann von Meyer in 1830. He then indicated the families, into which he proposed to divide the group, *viz.*:—

1. The *Megalosauridæ*, with the genera *Teratosaurus*, *Palæo-*

saurus, *Megalosaurus*, *Poikilopleuron*, *Lælaps*, and probably *Euskelosaurus*.

2. The *Scelidosauridæ*, with the genera *Thecodontosaurus*, *Hylæosaurus*, *Pholacanthus*, and *Acanthopholis*. (The omission of *Scelidosaurus* is of course accidental, as the family is founded on that genus.)

3. The *Iguanodontidæ*, with the genera *Cetiosaurus*, *Iguanodon*, *Hypsilophodon*, *Hadrosaurus*, and probably *Stenopelys*.

Although *Compsognathus* had many points of affinity with the *Dinosauria*, as in the ornithic character of its hind limbs, yet it differed from them in several important particulars. Professor Huxley therefore makes a separate group for it, the *Compsognatha* forming, with the *Dinosauria*, an order, the *Ornithoscelida*.

After treating of the *Ornithoscelida* in relation to other reptiles, he concludes to place them in that great division of the Reptilia which he calls *Suchospondylia*, in which the thoracic vertebræ have distinct capitular and tubercular processes. The Suchospondylia embraces the *Crocodilia*, the *Dicynodontia*, the *Pterosauria*, and the *Ornithoscelida*.

With regard to the relation of the *Ornithoscelida* to birds, Professor Huxley stated that he knew of no character by which the structure of birds, as a class, differs from that of reptiles, which is not foreshadowed in the *Ornithoscelida*.

Dr. Duncan's paper "On the Geography of Western Europe during the Mesozoic and Cainozoic periods," elucidated by their Coral-faunas, would seem to have been intended to create a discussion for the purpose of bringing out the younger Agassiz, who is over for a visit in Europe. Considerable misconception exists in the minds of even advanced naturalists, as to the species of corals peculiar to the deep sea, as contrasted with the reef, lagoon, and shallow-water species. Dr. Duncan contrasted the fauna existing in our seas with the extinct coral-fauna of the Secondary and Tertiary epochs, and pointed out that a correspondence of physical conditions in the deposition of certain strata was marked by the presence of similar organic remains; thus the presence of compound cœnenchymal species of coral indicated reefs, and their absence in places where simple or non-cœnenchymal Madreporaria are found, is characteristic of deep-sea areas remote from land.

Professor Alexander Agassiz thought the depth at which true reef-building corals are said to exist would be considerably extended. A reef is in the course of formation at the present time off the coast of Florida.

Mr. Davidson has determined nearly forty species of Brachiopoda from the pebble-bed at Budleigh-Salterton, near Exmouth, Devon, and has figured them with his usual accuracy and artistic skill in three beautiful plates. It is to be feared that, with certain

palæontologists, a difference in horizon is sufficient to constitute a difference in species; hence the zones of Ammonites, each marked by a different species, which is said *never* to occur above or below a certain narrow bed or horizon.

Professor Huxley would like to see the rise of a new race of palæontologists, relying simply on zoological characteristics, and not upon geological position. A considerable reduction in the number of species would, he thinks, undoubtedly result.

Although the term species is too often used where *variety* would be more appropriate, yet these distinctions—when kept within due bounds—have been found of great value in tracing out, by their characteristic fossils, the horizon of beds over widely-extended areas.

Mr. Searles V. Wood, jun., continues his researches on the Boulder-drift. He finds the Yorkshire Glacial clays are of two kinds; the lower containing chalk-debris abundantly, the upper containing chalk sparingly in its lower part, and gradually losing it upwards. The Boulders of Shap Fell Granite only occur in the Boulder-clay, without chalk. Mr. Wood ascribes their dispersion to the agency of floating ice during the submergence of the district.

The great chalky clay derived its chalk from the extrusion of a great sheet of land-ice over the sea, the chalk-mud being due to the abrading action of the ice.

The anniversary of the Geological Society of London was held on the 18th February, when the President announced that the Wollaston Gold Medal had been awarded to M. Deshayes, as an expression of the estimation in which his services to Palæontology and Geology (especially in regard to the classification of the Tertiary formation and its Molluscan fauna) are held by geologists of this country.

The balance of the Wollaston Donation-fund was presented to M. Marie Rouault, of the Geological Museum of Rennes, in aid of his researches upon the palæontology of the Devonian and Silurian rocks of Brittany.

Neither of the gentlemen was present, but both sent letters of thanks.

8. METEOROLOGY.

The subject which has secured to itself the most important papers published lately has been the wind-systems of the globe, a question which had been left at comparative rest for some time.

Mr. Buchan's paper "On the Mean Pressure of the Atmosphere, and the prevailing Winds over the Globe," appears in vol. xxv. of the 'Transactions of the Royal Society of Edinburgh,' and has been most carefully worked out. The mean monthly conditions of atmo-

spherical pressure at the sea level are first discussed, on the basis of all trustworthy observations which were accessible, and then the prevailing winds are similarly treated, but with reference only to direction, not to force. The results obtained are entered on charts for each month and for the year. The broad facts arrived at are that the wind flows in accordance with Buys Ballot's Law around the areas of barometrical depression and elevation, the motion being retrograde in the first case, direct in the other, and that it does *not* flow as a constant anti-trade at the earth's surface in high latitudes, as supposed by Maury. The position of the respective areas of barometrical disturbance varies very considerably from month to month, and is mainly determined by the thermal conditions of the globe at the respective seasons.

It will be seen that the ideas of Mr. Buchan are somewhat at variance with Dove's theory of the paramount importance of the Polar and Equatorial currents (as N.E. and S.W. winds) in regulating climates. He has, however, submitted this theory to a special test, as on calculating the directions of the prevailing winds at each station he finds that almost always there are *two* maximum directions shown, but that in only 30 per cent. of the stations do these directions belong to either of the above-named winds; so that it cannot be maintained that there is a general flow of the winds of the North Temperate Zone towards and from the Polar regions.

In the theoretical explanation of air-motion, given by Mr. Buchan, the chain of reasoning is not perfectly conclusive. He argues in this way: if motion in the lower strata of the atmosphere be in a definite direction, a compensating movement must exist at an upper level. The lower currents are determined by the course of the isobaric lines, therefore the upper currents may be inferred from these same lines "taken reversely together with the isothermal lines taken directly." He assumes that if, over any area, temperature near the ground be low, it must necessarily follow that pressure at a great height over the same area must be much reduced. This may perhaps be true, but it is far from being as yet proved, in the utter absence of the possibility of any experimental confirmation of the statement, as we know nothing of the vertical distribution of pressure.

Taking the paper as a whole, it is one of the most valuable contributions to the science which has appeared of late years, and the least that can be said of it is that the results are fully commensurate with the labour bestowed on the discussion.

The other paper to which we have referred is one by Dr. Julius Hann, "On the Winds of the Northern Hemisphere and their Influence on Climate," read before the Vienna Academy. In the first part of this discussion the wind-systems are explained on the hypothesis of Dove's two currents; the Equatorial, flowing over the sea; and the Polar over the land: but the variations in their respective

directions from true S.W. and N.E. are explained by the relations of pressure. That these variations do exist is shown by the fact that in the great continent, the coldest point of the windrose shifts through 108°, from N. 62° E. over the North Sea, to W. 44° N. in Eastern Asia. The warmest point shifts similarly through 61°. Corresponding changes are noticeable in the baric windrose, so that, as Buchan shows, the main directions of the wind are not S.W. and N.E. As to the effect on rain, it is found that the sea winds are always the rain bringers, and the land winds the contrary. Our driest wind is N.E.; that for Pekin as well as for Toronto is N.W. Part II. is a special application of the results contained in the tables to the peculiarities of climate of the respective stations.

The quarter has on the whole been rather barren of meteorological papers both here and on the Continent, but this deficiency has been more than supplied by some works of a general nature. Mr. Keith Johnston, jun., has just brought out a 'Handbook of Physical Geography,' as a companion to the 'Physical Atlas.' The chapters, three in number, relating to Meteorology are very compact and comprehensive. Much of what he says on winds has been adapted from Mr. Buchan's paper just noticed; but as regards climate, the account of the Range Lines is a reproduction of a very good paper by the author, which appears in vol. vi. of the 'Proceedings of the Royal Society of Edinburgh.' In this paper he has discussed the range of temperature from January to July all over the globe. This map is an entirely new idea, and a most useful one, as in the question of Range all the differences between insular and continental climates are involved. Thus in these islands the range is about 20°. At Yakutsk it is 106°. No part of the open ocean has a range above 40°, while the curves above 60° are confined to the great continents.

On the whole, Mr. Johnston finds, as a practical result, that in the Temperate Zone the West coasts of continents have 15° less range than the East coasts, and a similar contrast is noticed between the opposite coasts of inland seas and lakes. Thus the coasts of the Mediterranean, which *face* East, have 10° more range than those which *face* West. The same fact is noticed on the shores of Lake Superior.

Dove has at last published Part II. of his 'Klimatologische Beiträge,' twelve years after its predecessor. In this he furnishes the text and tables to the 'Atlas of Monthly and Yearly Isotherms,' which appeared in 1864. The first fifty pages are devoted to a brief discussion of the climate of Western Europe, which is very interesting, but hardly worthy of the author's reputation. If we test it by what he says of these islands, it is evident that the sources of information are old and not quite accurate, while the statements themselves bear signs of haste and carelessness. Thus we are told

that the hemispherical cup anemometer was invented by Osler, and improved by Dr. Robinson. Dove assumes that observations in London, Liverpool, and Dublin, represent our climate fairly, while the instances cited to prove the mildness of our climate fall far below the real facts of the case, especially in the vegetable world. This paper is followed by some remarks on the climate of the Polar regions, but the bulk of the work is taken up with Temperature Tables. These are most valuable, containing, as they do, for about 1200 stations the yearly, monthly, and seasonal means, with the extreme range of climate, as well as that from summer to winter. To these tables are appended others of the non-periodic variations, giving for more than 400 places the monthly means derived from several years' observation, and the deviations from those means observed in every year from 1856 to 1868. Remarks on the average and absolute variability of temperature follow, and the volume is concluded with a notice of some of the most remarkable exceptional seasons which have been recorded, such as severe winters, *e.g.* 1838, 1850, both of which, though cold in Europe, were warm in America; famous vintages, *e.g.* the Comet Year, 1811, and various other notabilia as regards climate. Many of these particulars have been already described by Dove in his 'Five-day Means of Temperature,' and in his papers read before the Berlin Academy; but the thanks of all meteorologists are due to him for having condensed such a mass of information into a work of 300 pages.

Professor Wild has followed up the publication of the 'Annales' for 1865 for the Russian stations by the announcement of the issue of a new serial, 'Repertorium für Meteorologie.' Formerly, a periodical under this title was published by the Geographical Society, at the suggestion of Kämtz, who was himself the author of most of the papers in it. The new 'Repertorium' is to appear under the auspices of the Academy, and to contain special discussions of the observations which are given in full in the 'Annales,' as well as independent papers on the Meteorology of Russia. The first part has already come out, and we find in it the instructions for the reorganization of the meteorological stations throughout Russia, with the tables for the reduction of observations on the basis of centigrade and metrical scales, which are to be substituted for the former tables drawn up by Kupffer. There is also an 'Essay on the Wind and Rain of Taurida and the Crimea,' by W. Koeppen. It is impossible to do more than allude to this paper, which is of the greatest value, being a discussion of a large accumulation of trustworthy observations.

It is curious that at the very time that Sir E. Sabine was discussing the climate of Barnaoul and Nertschinsk, as described in our last number, Lieutenant Rikatcheff was investigating the same subject, and he has published his results in a paper "On the Diurnal

March of Temperature" at the two stations in question, deduced from a series of twenty years' hourly observations. This paper forms part of No. II. of the 'Repertorium.' The results on the whole agree very well with Sir E. Sabine's. The climate of Nertschinsk is more truly continental than that of Barnaoul, but this difference is not exhibited to its fullest extent, owing to the difference in elevation between the two stations, the former being situated 2200 feet above the sea, as compared with 400 feet, the elevation of the latter.

The second report of the 'Norddeutsche Seewarte,' that for the year 1869, has just appeared. The main points brought forward by Herr von Freeden in this report have a special reference to Sailing Directions and to the practical pecuniary value of the office to the shipowners and traders of Hamburg. Accordingly, hitherto he has not been able to devote his attention to the general subject of ocean meteorology. However, the North German Parliament has now adopted the office, and several of the seaport towns of Prussia, such as Memel and Dantzic, have affiliated themselves to it as branch stations for the issue of instruments and registers.

The Report also contains interesting information relating to the Telegraphic Intelligence of Storms, sent to Hamburg by the Meteorological Office in London. From this it appears that the storm only preceded the warning on four occasions, three of which were accounted for by the intervention of Sundays, and that no intelligence at all of two other storms was received, owing in one case to a break-down on the telegraph line. Accordingly it will be seen that the storms which are felt on the Elbe almost invariably pass over these Islands. The instances in which the weather at Hamburg was undisturbed, subsequent to a warning, are all proved to have been accounted for by the fact that the storm died out before crossing the North Sea.

In conclusion, we have to notice the very important changes as regards meteorology which are in progress in France. M. Leverrier has been superseded, and his successor at the 'Observatoire Impérial' is M. Charles Delaunay. It is understood that for the future meteorology will form no part of the duties of the astronomical staff, and we hope that ere long this special science will receive in France a development worthy of its daily increasing importance.

9. MINERALOGY.

From the days when Montezuma presented Cortez with four *Chalchihuitls*, on his landing at San Juan de Ulua, it has been matter of dispute among mineralogists what was the true nature of the ornamental stone designated by this Mexican name. That it was held in the highest esteem is well known from many passages in the old chroniclers. It appears to have been worn only by the chiefs, and on the death of a great dignitary a chalchihuitl was placed in the mouth of the corpse. Indeed, the name of the stone became synonymous with all that was most valued; and according to one tradition, Quetzalcoatl—the law-giver, priest, and instructor of the Mexicans—was begotten by one of these stones, which the goddess, Chimalma had placed in her bosom. In recently laying before the Lyceum of Natural History of New York a fine collection of carved chalchihuitls, Mr. Squier took occasion to bring forward a body of evidence tending to identify the stone.* Molina, in 1571, defines the word as signifying *esmeralda baja*—an inferior emerald. Sahagun describes it as "a jasper of very green colour, or a common emerald." Montolina, in 1555, in enumerating the riches of Mexico, after speaking of gold, silver, and all metals and stones, refers to the chalchihuitls, and concludes by saying, "Las finas de estas son esmeraldas." Professor Blake has sought to identify it with the turquoise, but the author considers this not to be the true stone of the Mexicans and Central Americans. "The weight of evidence, in my opinion," says Mr. Squier, "goes to show that the stone, properly called chalchihuitl, is that which Molina defines to be 'baja esmeralda,' or possibly nephrite, 'a jasper of very green colour,' as Sahagun, already quoted, avers."

Two Indian meteorites have been subjected to an exhaustive examination by Professor Nevil Story Maskelyne, the Keeper of the Collection of Minerals in the British Museum—a collection which vies with Vienna and Calcutta in the number and variety of its meteoric specimens. One of the stones fell at Busti, between Goruckpoor and Fyzabad, on the 2nd Dec., 1852; and the other fell at Manegaum, in Khandeish, on the 26th July, 1843.† The Busti meteorite consists for the most part of enstatite, a silicate of magnesia, in which are imbedded small spherules of *Oldhamite*. This mineral is composed mainly of sulphide of calcium; and the presence of such a compound would seem to indicate that the conditions under which the ingredients of the meteorite were formed must have been very different from those met with on the surface of our globe.

* 'Observations on the Chalchihuitl of Mexico and Central America.' By E. G. Squier, M.A. New York, 1869.

† 'Proceedings of the Royal Society,' Jan. 13, 1870, p. 146.

Not only does it bespeak the absence of water and of oxygen; but having regard to the conditions needful for the production of this particular compound, the author thinks himself justified in pointing to the presence of some reducing agent, which operated during the formation of the constituents of the stone—such an agent as would be furnished by Graham's meteoric hydrogen.

Oldhamite forms spherules of a chestnut-brown colour, having a specific gravity of 2·58, and presenting a cubic cleavage. In some of these spherules there are minute gold-coloured octohedral crystals, which contain calcium, sulphur, and a rare metal—probably titanium. As a befitting compliment to the gentleman who forwarded the Busti meteorite to this country, Maskelyne describes this second mineral under the name of *Osbornite.*

Dr. Giovanni Strüver's studies in Italian mineralogy have lately been directed to the examination of the iron-pyrites of Piedmont and of Elba.* In the collection of the Engineering School of Turin, and of the University Museum in the same city, nearly 6000 specimens of Italian pyrites are to be found. The author has thus had ample materials for study, and that he has made good use of his opportunities is clear from his exhaustive monograph on the subject. He describes the various simple forms and combinations in which the Italian mineral occurs, including many newly-observed forms. It is notable that in 5603 specimens only three distinct simple forms were found. The memoir is illustrated by a series of fourteen plates.

Some few years ago, Herr Stein described a mineral under the name of *Staffelite.* It had the extraordinary composition of a hydrous phosphate and carbonate of lime, with a fluoride of calcium and traces of iodine. It occurred usually as a greenish incrustation, but was said to be also found in rhombohedral crystals. A similar substance has been met with in certain phosphorite workings near Offheim, in Nassau; and upon this crust of so-called staffelite were some fine clear crystals of apatite. Dr. Kosmann publishes an analysis of this apatite,† and assigns to it the formula: $5\,(3\,CaO.\,PO_5) + 2\,CaFl$. It is notable for containing as large a percentage as 4·52 of fluorine, and for the presence of magnesia. The author believes that staffelite is nothing more than an impure form of apatite rapidly deposited and contaminated with the salts of the mother-liquor from which it was evaporated. Dr. Kosmann also describes a new mineral under the name of *Lime Wavellite,* the composition of which is sufficiently indicated by its name.

In the Bergmannstroost mine at Altenberg in Silesia certain needle-like crystals are found penetrating brown-spar. Under the

* 'Studii sulla Mineralogia Italiana. Pirite del Piemonte e dell' Elba.' Torino, 1869.

† 'Zeitschrift d. deutschen geolog. Gesellschaft,' Bd. xxi., Heft 4, p. 795.

microscope they appear as strongly-striated rhombic prisms, with indistinct octohedral terminations. Formerly they were taken for antimony-glance, but when it was found that they contained lead, they were referred to either the species Jamesonite or Boulangerite. Dr. Websky has, however, recently shown that this mineral constitutes a new ore, which he proposes to designate as *Epiboulangerite.* It is a sulphide of antimony and lead, which may be thus formulated: $(Sb_4, Pb_6) S_{15}$.*

Professor Wöhler announces the discovery of minute crystals of diamond, with the native platinum of the Oregon; and diamonds are also reported from Bohemia.†

Ramelsberg has been led to compare the relation of gadolinite with several other species, and finds that datolite, euclase, and gadolinite form an isomorphous group.‡

10. MINING AND METALLURGY.

MINING.

THE mining interests of the country are promised rather more than the usual amount of attention from the British Legislature during the present sitting of Parliament.

The Secretary for the Home Department has introduced his "*Mines Regulation and Inspection Bill*," which was read for the second time on the 21st of February.

Lord Kinnaird, on Thursday, the 17th of February, introduced a Bill to the House of Lords, which is an attempt to apply the "Mines Regulation Act of 1870" to the metalliferous mines of the country.

The President of the Poor Law Board has intimated his intention of bringing again, before the House of Commons, the consideration of the question of rating metalliferous mines for the support of the poor.

The Government Mines Regulation Bill, introduced by the Home Secretary, professes, in its broader features, to fix definitely the responsibility in connection with the workings of all collieries, to secure increased safety in the mine, and to promote the better education of the mining population.

Last year the Mining Association of Great Britain, and the Colliery Inspectors, representing the Home Secretary, agreed to the following provision:—"That in every coal and ironstone mine an amount of ventilation shall be constantly produced, adequate to

* 'Zeitschrift d. deutschen geolog. Gesellschaft,' Bd. xxi., Heft 4, p. 747.
† 'Comptes Rendus,' 24 Jan., 1870, p. 140.
‡ 'Zeitschr. d. d. geol. Gesell.,' Bd. xxi., Heft 4, p. 807.

dilute and render harmless noxious gases, to such an extent, that the working places of the pit's levels and workings, and the travelling roads to and from the working places, shall be in a fit state for working and passing therein, *but that no owner, agent, or other person shall be held to have contravened this regulation, unless it shall be shown that all reasonable precautions have not been taken.*" This saving clause has been altered in the present Bill to:—"Provided that no owner, agent, or other person shall be held to have acted in contravention of this regulation, if it is shown that all reasonable precautions have been taken by the owner, agent, or person who is so charged."

This proposition is regarded as the turning-point of Mr. Bruce's Bill, and already loud is the cry amongst colliery owners and agents against it. "It cannot be supposed for a moment," says the 'Colliery Guardian,' "that they (the coal-owners) can take any other course than that of opposing it to the utmost, nor will they find any difficulty in showing that English legislation contains no precedent for an enactment which assumes that every person charged is guilty, and may be punished as such, unless he can prove himself innocent."

The question of *responsibility* is the one over which the battle will be fought. Every one is, of course, desirous of relieving himself from this burthen; and it is, indeed, a heavy one in some of our collieries, where the lives of hundreds of men are dependent entirely on the unceasing attention of a single mind. If the colliery owners and agents can relieve themselves of this by any pressure which they can bring upon our legislators, they will most certainly exert themselves to the utmost to secure the necessary force. We cannot ourselves see any alternative. The responsibility of securing the most perfect appliances, in every division of the workings of a colliery, must rest somewhere, and it cannot be allowed to be capable of being shifted from one individual to another. In every colliery some head-man must be made responsible, and the Bill does not appear unjust on this point, for if this responsible head can show, after an accident has occurred, that every proper precaution had been taken, he will be held to be guiltless of any blame.

The employment of women and children, the payment of wages, the special rules and provisions as to arbitration, are all carefully dealt with in this Bill. The clauses which relate to inspection do not appear to us to be entirely satisfactory. Much has been said of the inability of twelve inspectors to visit, within the year, the 3000 collieries in the United Kingdom. It does not appear to us to be desirable that they should do so, but an earnest and intelligent man may make himself perfectly familiar with his district, without subjecting himself to the labour, or the coal-owner to the annoyance, of prying into the details of the subterranean workings. Lord Elcho remarked,—"The name of 'Inspector' was a misnomer, for the in-

spectors did not profess to go into the mines, they merely held an inquiry when an accident had occurred. Accordingly they might with more truth be called '*Accident Inquirers.*'" We fear a good and sufficient reply cannot be given on this point to Lord Elcho. Mr. Bruce, anticipating, as he could well do, from the discussions of last year, on the same subject, attempted to answer this, but all that he said, cannot be regarded as other than ingenious special pleading.

Mr. Lancaster referred to many of the causes leading to our present imperfect system of working for coal. To these we can only direct attention. His concluding remarks are of too much value not to be quoted:—"While many of the managers of mines were men of first-class education, and also of great practical experience, it was necessary that the younger men should receive a technical as well as a practical training. He hoped that as to some of these questions, the Home Secretary would adopt a much bolder course than that which he had yet taken, and would not hesitate to carry out the full recommendations which had been made."

Lord Kinnaird's Bill provides for the establishment of General Rules and Special Rules for Metalliferous Mines as nearly similar as possible to those proposed for collieries. It is evident from this that the different conditions of the two systems of mining cannot be correctly understood by his Lordship. The Bill provides for the effective ventilation of the metal mines, the depositing of plans with the Secretary of State (there never has been any objection to furnishing plans, as the large collection already in the hands of the Government in the Mining Record Office proves), and for such arrangements as are thought to be conducive to the health of the miners.

"Our Future Coal Supply" has claimed the attention of the South Staffordshire and East Worcestershire Institute of Mining Engineers, Mr. Richard Latham and Mr. George Spruce contributing two papers containing much important matter relative to the future workings of the thick coal of Staffordshire, and the probable extension of the Staffordshire field towards the coal-field of Shropshire.

Mr. Walter Ness, of Pelsall, also read a paper "On part of the Coal-field of Fife, N.B.," in which he proved, probably beyond much doubt, a large extension of this coal-field beyond the present workings. From this he adventures farther from the shore, and says:—"If we take the total area of the Forth, where we have reason to believe those Coal-measures exist in their entirety, we have about 180 square miles in their entirety . . . and we get 12,672,000,000 tons. Taking the other parts of the nation (sea-bed ?) in like manner available, opposite Northumberland, Durham, and Yorkshire, and under the German Ocean, also opposite Ayrshire, Cumberland, Lan-

cashire, and the Bristol Channel, on the west coast, as jointly capable of yielding a similar quantity of coal to that of the Firth of Forth, we shall then have 25,344,000,000." These are large figures—of their value we can only judge by the exactness of other statements made in this paper. "The investigation of the Royal Commission happily assures us that there is coal enough in store for several generations to come." Such is the opening paragraph of Mr. Walter Ness's paper. The fact being that the Royal Commission has not given one word of assurance in any form—and, we can state upon authority, that they are not yet in a position to do so.

METALLURGY.

There does not appear to be any novelty worthy of notice. The arrangements made upon the termination of one of the Bessemer Patents have led to considerable activity in the manufacture of Bessemer steel, and probably the result will be that, ere long, steel rails will almost entirely have superseded the iron ones, to which we have been so long accustomed.

A few interesting experiments are in progress, but none of the results yet obtained are sufficiently reliable to warrant our placing them on record.

11. PHYSICS.

LIGHT.—It is a well-known fact that M. Schroetter proved that the action of sunlight converts ordinary phosphorus into red amorphous phosphorus. Sulphur, according to M. Lallemand, is similarly affected by the direct action of sunlight, inasmuch as the sulphur previously soluble in sulphide of carbon, and crystallizable, is converted into an amorphous modification insoluble in sulphide of carbon. The author placed a concentrated solution of sulphur in sulphide of carbon in a sealed tube, and exposed that tube some time to the action of the sun's rays, concentrated by a lens; this causes a copious precipitation of sulphur as an amorphous insoluble matter.

Mr. Burt has examined the action of coloured light upon the *Mimosa pudica*. The plants are placed under glass jars constructed of variously-coloured glass. The chief fact observed in respect of these very sensitive plants is that by being covered with a green-coloured glass jar, the plant rapidly becomes insensible, and dies in a very short time.

The Rev. Father Secchi, after referring briefly to his former observations of the spectrum exhibited by Uranus, states that the

spectrum of Neptune consists chiefly of three lines, or bands, placed near the green, and that its light is entirely devoid of red; this is confirmed by the colour exhibited by the planet when seen through a telescope, which is a sea-green.

M. Feil has exhibited before the French Academy samples of perfectly homogeneous heavy flint-glass for optical purposes free from any bubbles or defects, and in masses weighing from 25 to 35 kilos. The process whereby this is obtained is not explained; but the statement is made that the crucibles having been protected from the effects of the lead, a heavier glass even than Faraday's can be made. The maker sent also a set of samples of beautifully-made artificial precious stones, not mere specks, but of good size. The aluminates of lime, of baryta and lime, of lead and of bismuth, are proposed for flint-glass; and the aluminates of magnesia and the silicates of magnesia and alumina for crown-glass.

M. Bontemps, the managing director of the celebrated glass works at Choisy-le-Roi, has arrived at the following results in connection with the coloration of glass under the influence of direct sunlight:—Within three months after having been exposed to sunlight, the best and whitest glass made at St. Gobain is turned very distinctly yellow; extra white glass (of a peculiar mode of manufacture) has become even more yellow, and gradually assumes a colour known as *pelure d'oignon;* glass containing 5 per cent. of litharge was also affected, but far less perceptibly; crystal glass, made with carbonate of potassa (the other varieties referred to contain carbonate of soda), litharge and silica, was not at all affected; English plate-glass, made by the British Plate-Glass Company, and exhibiting a distinctly azure-blue tinge, remained also unaffected. The author attributes the coloration, which begins with yellow and gradually turns to violet, passing through red *pelure d'oignon*, to the oxidizing effects of the sun's rays upon the protoxides of iron and manganese contained in glass.

M. Schinz states that platinum brought to bright white heat by means of the ignition of a mixture of hydrogen and carbonic oxide gases, yields a light which, in relation to good coal-gas, is as 1·24 to 1·0.

Professor B. Silliman has examined, in a lengthy series of experiments, the relation between the intensity of light produced from the combustion of illuminating gas and the volume of gas consumed. His experiments prove, among other matters, this theorem—that the intensity of gas-flames (*i. e.* illuminating power) increases, within the ordinary limits of consumption, as the square of the volume of the gas consumed. The chief point of interest, for the consumer of gas, to be deduced from the data here presented is, that where it is important to obtain a maximum of economical effect

from the consumption of a given volume of illuminating gas, this result is best obtained by the use of burners of ample flow.

HEAT.—According to MM. Troost and Hautefeuille, carbon when combining with oxygen, only gives out 8000 caloric units; boron, under the same conditions, yields 14,400 caloric units; while, when boron combines with three equivalents of chlorine, 104,000 caloric units represent the heat set free.

The heat disengaged by the combination of 1 grm. of amorphous silicium with oxygen is 7830 units, with chlorine 5030. When 1 grm. of chloride of silicium reacts upon 140 times its weight of water, it is 2915; the heat disengaged when 1 grm. of amorphous silicium is converted into crystallized silicium is 290 units of heat.

Dr. St. Claire-Deville states that the oxygen dissolved during the fusion of platinum causes this metal to present the same phenomenon as molten silver—*viz.* scintillation and spirting while in the molten state.

In a paper "On the Heat given off by the Moon's Rays," M. Zantedeschi states that, as far back as the years 1685 and 1781, the Italian *savants* Geminiano, Montanari and Paolo Frisi proved the existence of rays of heat emitted by the moon, by means of lenses and ordinary thermometers. The author refers to his observations made some twenty years ago, when he applied thermo-electric apparatus, as well as spirit thermometers and lenses, and obtained results fully confirming those made and recorded by the Italian *savants* just alluded to.

In Germany the doors of the steam-boiler furnaces are now very generally provided with square pieces of mica, properly fastened, by means of which the fireman is enabled to observe the fires without the necessity of opening the furnace-doors too frequently, which is injurious, on account of interfering with the draught and proper course of combustion of the fuel, by reason of the access of irregular currents of cold air. Mica withstands a very high temperature; and the accidental breakage of the squares of this substance is guarded against by a properly-constructed iron-wire guard outside.

Dr. Ziurek states that gas from the brown coal from Furstenwald, five miles from Berlin, will shortly be made on the spot, and collected in Berlin in twelve gas-holders, each of a capacity of 750,000 cubic feet. The gas will be carried, as usual, in underground mains, and chiefly applied for heating purposes. 3000 cubic feet of this gas have a heating power of one-third of a ton of best coals, and are equal to 1 ton of best Prussian brown coal. 1000 cubic feet of this gas will cost about 5*d.* in Berlin; and the equivalent value of the heating power of this gas as compared with a

ton of coals will be 4*s.* 6*d.* The works have been made to supply 950,000,000 cubic feet of gas annually, or at the rate of $2\frac{2}{3}$ millions of cubic feet daily.

Electricity.—A thermo-electrical apparatus, with galena and iron, has been made by MM. Mure, Clamond, and Gaiffe. According to the results of their experiments, this apparatus deserves the attention of all who require galvanic batteries, since regularity and steadiness of action are here combined with economy and the absence of inconvenient vapours.

For telegraphic work or domestic purposes, where a constant galvanic current is required with little trouble (electric bells, fire and thief detectors), the writer has found the new battery known as the Leclanché cell to be most perfect in action. The main feature is that peroxide of manganese is used with zinc (not amalgamated) and an aqueous solution of an alkaline salt, chloride of ammonium being preferred. The cells are of three sizes: the smallest, with a porous pot 4·3 inches high, can accomplish an annual electric work which may be represented by 620 grains of copper reduced in the voltameter; the medium size, with a 6-inch porous pot, can reduce from 950 to 1000 grains; while the large size gives a work equal to 1500 or 2000 grains.

F. Zaliwski has described a galvanic element with three fluids. This contrivance consists of two porous cells placed one inside the other, and surrounded by another suitable vessel. The inner vessel contains nitric acid and a piece of carbon, the intermediate vessel contains sulphuric acid, and the outer vessel a solution of sal-ammoniac in water and a piece of zinc. This author states that this arrangement is superior to a Bunsen cell.

The phenomena of atmospheric electricity at the island of Haiti, or St. Domingo, as it is also called, are of a very striking character. According to Mr. Ackermann, who has during a series of five years made meteorological observations at Port-au-Prince, there have, on an average, been 129 days of each year either severe thunderstorms or other very marked electrical phenomena, especially during the months of May, July, August, and September. Severe thunderstorms more frequently occur during day than night-time. The year 1868 was especially remarkable for severe thunderstorms; during one of these, lasting for forty-five minutes, 400 lightning flashes were distinctly seen.

A company has been formed in America with the view of covering other metals, by galvano-plastic means, with a more or less thick coating of pure nickel. Since that metal is very hard, it resists, even in thin layers, rather rough usage; it is not oxidized, even in contact with water, at the ordinary temperature, and the metal as-

sumes a brilliant polish if required. The method employed for the deposition of nickel was treated of at a meeting of the French Academy. The company alluded to have established a branch manufactory at Paris, under the management of M. Gaiffe.

M. Gaiffe calls attention to the fact that the presence of even the smallest quantity of potassa, or soda, or alkaline earths in the bath containing the nickelizing preparation is injurious to effect a properly-adhesive coating of the metal. The use of perfectly pure double chloride of nickel and ammonium, or of perfectly pure sulphate of nickel and ammonium, and, moreover, of pure nickel as one of the electrodes, is required. By these means the nickel is made to adhere regularly and strongly, and only requires polishing after the metal, coated over, is taken from the bath. On the other hand, M. Becquerel now states that he has purposely repeated some of his former experiments, with the express view of ascertaining whether the statement made by M. Gaiffe, concerning the injurious action of the presence of potassa, be correct or not. The result of experiments is that the presence of potassa is not at all injurious to, and in no wise affects, the deposition of nickel, since the double sulphate of nickel and potassa can be applied, as well as the double sulphate of nickel and ammonia; but if the positive electrode is not made of nickel, it is necessary to add free ammonia, in order to saturate the sulphuric acid, which is set free.

M. Scoutetten states that the accidental striking of lightning on the house of a vineyard proprietor caused the rupture of several large hogsheads containing wine, which found its way into a cavity existing in the cellar of the house. The owner imagined his wine lost and spoiled, but found, to his astonishment, that the wine, instead of having been deteriorated, had become better than it was before. This accidental occurrence having come to the knowledge of General Marey-Mouge, caused M. Scoutetten to be consulted, and a series of experiments instituted with various kinds of wine, of inferior as well as medium quality. A series of experiments, made on the large scale, and with various sources of electricity, led to the result that electricity, under whatever form applied (whether as a regular current, or a succession of discharges accompanied by sparks), improve wine, rendering it mellow and mature. As to the mode of action of this agent, the author thinks that the bitartrate of potassa present in wine is decomposed, the potassa set free saturates the acids of the wine, and the free tartaric acid, reacting upon the fatty matters present, favours the formation of the ethers which constitute the bouquet of the wine. Moreover a small quantity of water is decomposed, and the oxygen thereof reacts upon some of the constituents of the wine, thereby forming new compounds which are peculiar to old wines.

12. ZOOLOGY—ANIMAL PHYSIOLOGY AND MORPHOLOGY.

Physiology.

Researches on the Relation of Heat to Work in the Human Body.—Professor Pettenkoffer, of Munich, has undertaken an investigation into the amount of heat produced by the human body when at rest and when at work, which promises to give highly important results. The wonderful experimental chamber which King Max had constructed for Pettenkoffer's work is to be made use of. The chamber, which is about 10 feet square, is fitted with an iron tube through which the air is regularly drawn by means of an aspirator worked by a steam-engine, the air being accurately measured in a gas meter. Smaller aspirators bring measured quantities of the air through analysis-tubes in which the quantities of carbonic acid, water, hydrogen and carburetted hydrogens (the last two by combustion with spongy platinum) are determined in the air both before and after it enters the chamber. The small aspirators, bringing a small but constant fraction of the whole air passed into the chamber through the analysis apparatus, the quantities of carbonic acid gas, water and hydrogen in the whole can be readily calculated. It is now intended to take the temperature of the air before and after it traverses the chamber, and in this manner to ascertain the actual amount of heat produced by the human body when at rest and when at work, and in relation to the amounts of the various excretions. For this purpose a smaller chamber has been constructed within the first made, and arrangements adapted by means of non-conductors, &c., to prevent, as far as possible, the loss of heat. It is found that there is a constant loss of about 40 per cent. of the total heat with two candles burnt in the chamber; of about 50 per cent. with four. The heating effect upon the air passed through the apparatus is determined before each experiment with stearine candles of known weight, and thus when a man is placed in the chamber instead of the candles, you get his heating effect in terms of stearine candles, and this is, of course, at once convertible into units of heat. The preliminary experiments with candles promise very accurate and satisfactory results from this method. As an apparatus for chemical analysis the chamber is perfect; so perfect that the percentage composition of a candle can be determined as accurately by burning it in the chamber, and the fractional analysis, as by the most complete direct combustions. The determination of the heat produced is a matter of more difficulty on account of the fluctuations of external temperature and the delicacy of the thermometers which must be used; but Professor Pettenkoffer has used every precaution, and succeeded in rendering the apparatus efficient. The experiments are now in

progress; a man is to be kept in the chamber for six to eight hours, and the work done is in the form of crank-turning.

The Absence of Currents in Uninjured Inactive Muscle.—Professor Hermann states that if the gastrocnemius muscle of the frog be so prepared for investigation that no contact between the cutaneous secretion and the surface of the muscle takes place, then, with an exceedingly delicate galvanometer, only the very smallest deflection of the needle is obtained. He concludes, therefore, that by still greater care muscles can be obtained perfectly free from currents, and regards previous observations of muscular currents as having a very different significance to what has been supposed, being really artificial phenomena due to certain accidents of manipulation.

Pasteur's Views on Fermentation.—Professor Liebig disputes Pasteur's theory that the decomposition of sugar in fermentation depends on the development and multiplication of yeast-cells, and that fermentation is only a phenomenon accompanying the vital processes of the yeast. Liebig considers that Pasteur's researches have not explained fermentation, but have only made known another phenomenon—the development of yeast—which equally requires explanation.

Physiology of Sepia.—A series of interesting experiments have been made by M. Bert on this subject. He finds that the excision of the large supra-œsophageal ganglion-mass causes no pain or inconvenience to the animal, but simply deprives it of *voluntary* motion. He hence infers it to be equivalent to the vertebrate cerebrum. The contents of the salivary glands, as also of the liver and pancreas (so-called), are acid. The peritoneal cœca excrete uric acid. Strychnia and curare have the same effect on this animal as on vertebrates.

Morphology.

Commensalism.—Professor Van Beneden, in an interesting address to the Belgian Academy of Sciences, proposes this word to distinguish a group of animals hitherto confused with what he would term veritable parasites. Commensal parasites, or commensals, do not feed *on* the animal with which they are found, but *by* it: they are not destructive or injurious to their hosts, but often are of service, if we may judge from the constancy of association and the satisfaction which both parties seem to enjoy. Professor Van Beneden distinguishes fixed and free commensals. Among the fixed we may mention the various barnacles which are attached to whales and sea-turtles; the *Anemone parasitica*, which invariably is fixed to a shell inhabited by a particular species of Hermit-crab, said to exhibit great affection for the polyp it bears on its back; many Polyzoa and Hydrozoa, which attach themselves to the carapaces of crustacea, especially the hairy-looking *Dromia* of our southern coasts.

Free commensals are the most numerous. Little fish live *inside* jelly fishes, without incommoding their host, or being incommoded; a whole troop of a particular species may be thus sometimes seen. Similarly a fish called Fierasfer lives inside a Holothurian, and in a large species of Anemone the same observation has been made. Dr. Semper has described, in addition to the little fish inhabiting Holothuriæ, several molluscs, which also live in this way; whilst Müller made known *Entoconchon*, from the *Synapta;* and *Stylifer* lives on *Echinus.* The Remora is a remarkable instance of commensalism. This strange fish, by means of the sucker on the back of its head, attaches itself to other fish and to whales, sometimes to ships, and is thus carried along through rich feeding-grounds. The inhabitants of Mozambique use this fish as a means of capturing others, tying a string to it and letting it out into the sea, when it attaches itself to some unsuspecting inhabitant of the ocean, which, together with the Remora, is speedily dragged to shore. The little crustacean (*Pinnotheres*), which lives inside the shell of the common edible mussel, has long been known, and various species in this and other countries have excited speculation and fable. There is no doubt a most cordial understanding between the little crab and its host; and though we cannot go so far as to believe that the crustacean acts as a watchman for the Mytilus, warning it when to close its shell, it is yet very evident that there is a close relationship of reciprocal advantage existing between the two. *Chætogaster*, the little worm which crawls about on *Lymnæus* and *Planorbis*—the common water-snails of our ponds—is a good example of a commensal, sticking very close to his friend, feeding on the *Cercariæ* (*true* parasites) and other matters which accumulate on the snail's body. Many tubicolous Annelids have a commensal, or messmate, who shares their residence; such are many scale-bearing Annelids —the Polynöina, which ensconce themselves in the tubes of *Chætopterus insignis*, of *Terebella nebulosa*, and others. One Polynöe was many years since described by Professor Huxley as living on the common Cross-star, and hence named *P. astericola.*

The distinction between *commensal* and *parasite* is this, that the parasite uses his host for food; whilst the animals which are mentioned above, and many others enumerated by Professor Van Beneden, though often termed parasitic, do not feed upon the tissues of the animal with which they live, and hence have a very different relation to them. Their food consists often of what is rejected by, or is even hurtful to, their hosts; and though the line between them and true parasites may not be easy to draw sharply, it is yet useful to recognize them under a distinct name, as proposed by Professor Van Beneden.

A New Genus of Cervidæ.—Mr. R. Swinhoe, who, as consul at Formosa and various stations on the Chinese coast, has done most

active and important work in the investigation of the fauna of that part of Asia, described recently to the Zoological Society of London, a new form of deer, common on the islands at the lower part of the river Yangtse-Kiang, near Ching-Kiang, into the markets of which city it is often brought, though it appears hitherto to have escaped the observation of naturalists. This deer is distinguished by the long canines and the total absence of horns in both sexes. Mr. Swinhoe proposes to form a new genus for the reception of this remarkable form, and gives it the name *Hydropotes inermis*.

Animals presenting two distinct Sexual Forms.—From the time when the so-called alternation of generations became known to zoologists, they have been familiar with various species of lower animals which reproduce sexually under one form, and a-sexually under a totally different form, the form presenting agamic reproduction being often so different from that in which sexual maturity is ultimately attained, that at one time the two phases of the species have been referred even to different classes of the animal kingdom. The a-sexual Aphides, whose offspring become male and female adults; the Cecidomyia larvæ, producing a-sexually larvæ like themselves, which become eventually sexually mature flies; the various Entozoa and the Annelids of the family Syllidæ, which reproduce rapidly by fission, whilst at certain times individuals endowed with sexual organs, and differing most markedly in their setæ and other characteristics are produced,—are familiar instances. Lately, by the researches of Leuckart, Mecznikow, and Schneider, we have been made acquainted with a nematoid worm parasitic in the frog, which presents the remarkable condition, previously unparalleled in science, of two sexual forms: the first, in which there are distinct males and females, is a free living form; the second, to which the eggs of this bisexual generation give rise, is hermaphrodite, but at the same time truly sexual in its reproduction, according to M. Schneider, in which it differs from all previously recorded cases of alternation of generations. M. Claus asserts the same of the Nematoid, *Leptodera appendiculata;* and the Acaleph *Carmarina* has since been described as presenting the same condition of things. M. Claparède, of Geneva, amongst his other discoveries in the Bay of Naples, has brought to light a most interesting case among the highest Annelids of an animal presenting two distinct sexual generations. The *Nereis Dumerilii* is the worm to which these observations refer. For some time this species has been a puzzle to zoologists, and M. Malmgren had already detected its relation to Heteronereis; but the problem has been fully investigated by M. Claparède. He finds that there are absolutely two forms of sexually mature *Heteronereis* (each having its own males and females, as in nearly all Polychœtous Annelids): one small and very agile, swimming on the surface of the sea, and thus widely dispersing its reproductive elements; the

other much larger, but less agile, which never leaves the sea-bottom, and fitted rather to reproduce the species in a fixed locality. The eggs of the two forms of *Heteronereis* are not at all similar; but the zoosperms are identical in the two. This, however, is not the most remarkable part of the case; for it appears that these two forms of Heteronereis are neither more nor less than developed forms of the *Nereis Dumerilii*, which has also a sexual condition (consisting of both males and females) as a Nereis. We have in the *Nereis Dumerilii*, according to M. Claparède, a worm which is adult both as Nereis and Heteronereis, and has probably two Heteronereidan forms. An important question is whether a worm which has arrived at sexual maturity as a *Nereis* can lose again its sexual characters, and become a Heteronereis; or whether we must consider that a worm once arrived at maturity as a Nereis can never itself become a Heteronereid, but only the worms which it produces are destined for this condition. The question is one of importance, which must be solved by study of worms kept in the aquarium. Undoubtedly we have here one of the most astonishing cases of protean diversity of specific form ever brought before naturalists—of a kind, indeed, totally unexpected. The history of the Axolotl (chronicled by us some time since) presents a sort of parallel to this case; but it may prove that the resemblance is not so close as we might at present suppose.

M. Dumeril has shown that the Amphibian Axolotl of Mexico reproduces when in its larval condition with perennial gills, as known in the tropical region of Central America; and also that in colder regions losing these gills, it assumes the more perfect Salamandroid form, and is reproductively active in that condition. The perennibranchiate condition may be compared to the Nereis-form, the Salamandroid to the Heteronereis; but it is to be observed that the differences are much greater in the case of the two forms of the worm than in the Amphibian: also we have no parallel to the second Heteronereis form of the *Nereis Dumerilii*, which, by the way, is well named *à propos* of the distinguished herpetologist who has made known the sexual peculiarities of *Siredon.*

Miscellaneous.—The eminent comparative anatomist Professor Keferstein, of Göttingen, has died at the early age of thirty-seven. He was an active worker, from whom much in bibliological science had been already gained, and from whom much was to be expected.

The Sars Fund.—A subscription has been started for the family of the eminent Scandinavian zoologist, Michael Sars, whose death occurred last year. Whoever knows anything of marine zoology knows of the work of Sars and of his eminent son, G. O. Sars. In France and Germany the subscription is progressing, and in this country Mr. J. Gwyn Jeffreys has undertaken to receive contributions. We shall be glad to hear that the appeal to English savans has been successful.

Quarterly List of Publications received for Review.

1. On Comparative Longevity in Man and the Lower Animals. By E. Ray Lankester, B.A. *Macmillan & Co.*
2. Reports on the Progress of Practical and Scientific Medicine in different parts of the World. Edited by Horace Dobell, M.D., Senior Physician to the Royal Hospital for Diseases of the Chest. *Longmans, Green, & Co.*
3. Geology and Revelation; or, The Ancient History of the Earth considered in the Light of Geological Facts and Revealed Religion. By the Rev. Gerald Molloy, D.D., Professor of Theology in the Royal College of St. Patrick, Maynooth. *Longmans, Green, & Co.*
4. Our Domestic Fire-places. New Edition, entirely re-written and enlarged. By Frederick Edwards, jun. *Longmans, Green, & Co.*
5. Discussion of the Meteorological and Magnetical Observations made at the Flagstaff Observatory, Melbourne, during the years 1858–1863. By George Neumayer, Ph.D., late Director of the Flagstaff Observatory, &c. *Mannheim: J. Schneider.*
6. Education and Training, considered as a subject for State Legislation. By a Physician. *J. Churchill & Sons.*
7. Reliquiæ Aquitanicæ; being Contributions to the Archæology and Palæontology of Périgord, &c. By E. Lartet and H. Christie. Edited by T. Rupert Jones, &c., &c. *H. Baillière.*
8. Statistics of New Zealand for 1868. Printed by order of the New Zealand Government. *Wellington: G. Didsbury.*
9. The Philosophy of the Bath, with a History of Hydro-therapeutics and of the Hot-air Bath from the Earliest Ages. By Durham Dunlop, M.R.I.A. *Dublin: Moffat & Co.*
10. Christianum Organum; or, the Inductive Method in Scripture and Science. By Joseph Miller, M.A. Introduction by J. H. Gladstone, Ph.D., F.R.S. *Longmans, Green, & Co.*
11. Choice and Chance. By Rev. W. A. Whitworth, M.A., Fellow of St. John's College, Cambridge. *Cambridge: Deighton, Bell, & Co.*
12. Preliminary Field Report of the U.S. Geological Survey of Colorado and New Mexico. By F. V. Hayden, U.S. Geologist. *Washington: Government Printing Office.*
13. Geological Report of the Exploration of the Yellowstone and Missouri Rivers. By the same Author.

14. The Book of Nature and the Book of Man. By Charles O. G. Napier, of Merchiston, F.G.S., &c. Illustrated with photographs and numerous woodcuts. *J. Camden Hotten.*

PAMPHLETS AND PERIODICALS.

Memoirs of the Geological Survey of India, published under the Direction of Thomas Oldham, LL.D., &c. *Calcutta.*

Report on the Filtration of the Water of the Hooghly. By David Waldie, F.C.S.

Analysis of the Khettree Meteorite, with an Account of its Fall. Same Author.

Reports of the Mining Surveyors and Registrars of Victoria. *Melbourne: John Ferres.*

On the Geographical Distribution and Physical Characteristics of the Coal-fields of the North Pacific Coast. By Robert Brown, F.R.G.S., Commander and Government Agent of the first Vancouver Exploring Expedition, &c., &c. *Edinburgh: Neill & Co.*

Observations on the Chalchihuitl of Mexico and Central America. By E. G. Squier, M.A., &c., &c. *New York.*

Dr. Walter's Doctrines of Life. Reply to London 'Lancet.' (From 'St. Louis Medical and Surgical Journal.')

A Physical Theory of Animal Life. A Review by Julian.

On the Identity of the Vital and Cosmical Principle. By R. Lewins, M.D.

The Nature of Man Identical with that of other Animals. By Julian.

On Colour Tests as Aids to Diagnosis. By John Day, M.D. From the 'Australian Medical Journal.'

Report of the Committee for the Purpose of Investigating the Rate of Increase of Underground Temperature Downwards, in various Localities, of Dry Land and under Water. Professor Everett, D.C.L., F.R.S.E., Secretary.

An Investigation into some previously undescribed Tetanic Symptoms produced by Atropia in Cold-blooded Animals, with a Comparison of the Action of Atropia on Cold-blooded Animals and Mammalia. By T. R. Fraser, M.D. *Edinburgh: Neill & Co.*

Midland Steam-Boiler Inspection and Insurance Co.'s Report.

Annual Report of the Secretary of the Interior for 1869. *Washington.*

Notes on Books (Quarterly List and Analysis). *Longmans.*

Microscopic Objects Figured and Described. No. 1, January, 1870. By J. H. Martin, Secretary, Maidstone and Mid-Kent Natural History Society. *Van Voorst.*

The Food Journal; a Review of Social and Sanitary Economy and Monthly Records of Food and Public Health.
London: J. M. Johnson & Sons, 3, Castle Court, Holborn.

Revue Bibliographique Universelle. *Paris: 77, Rue de Bac.*

The American Naturalist. Peabody Academy of Science. *Salem, Mass.*

Scientific Opinion.

The Geological Magazine.

The Photographer's Annual and Almanac for 1870.
J. W. Green, 54, Paternoster Row.

PROCEEDINGS OF LEARNED SOCIETIES, &c.

Proceedings and Papers of the Kilkenny and South-East of Ireland Archæological Society. *Dublin: McGlashan & Gill.*

Transactions of the Edinburgh Geological Society.
Edinburgh: Neill & Co.

Proceedings of the Literary and Philosophical Society of Liverpool. (1868-9.) *London: Longmans.*

Proceedings of the Manchester Literary and Philosophical Society. (Extract.)

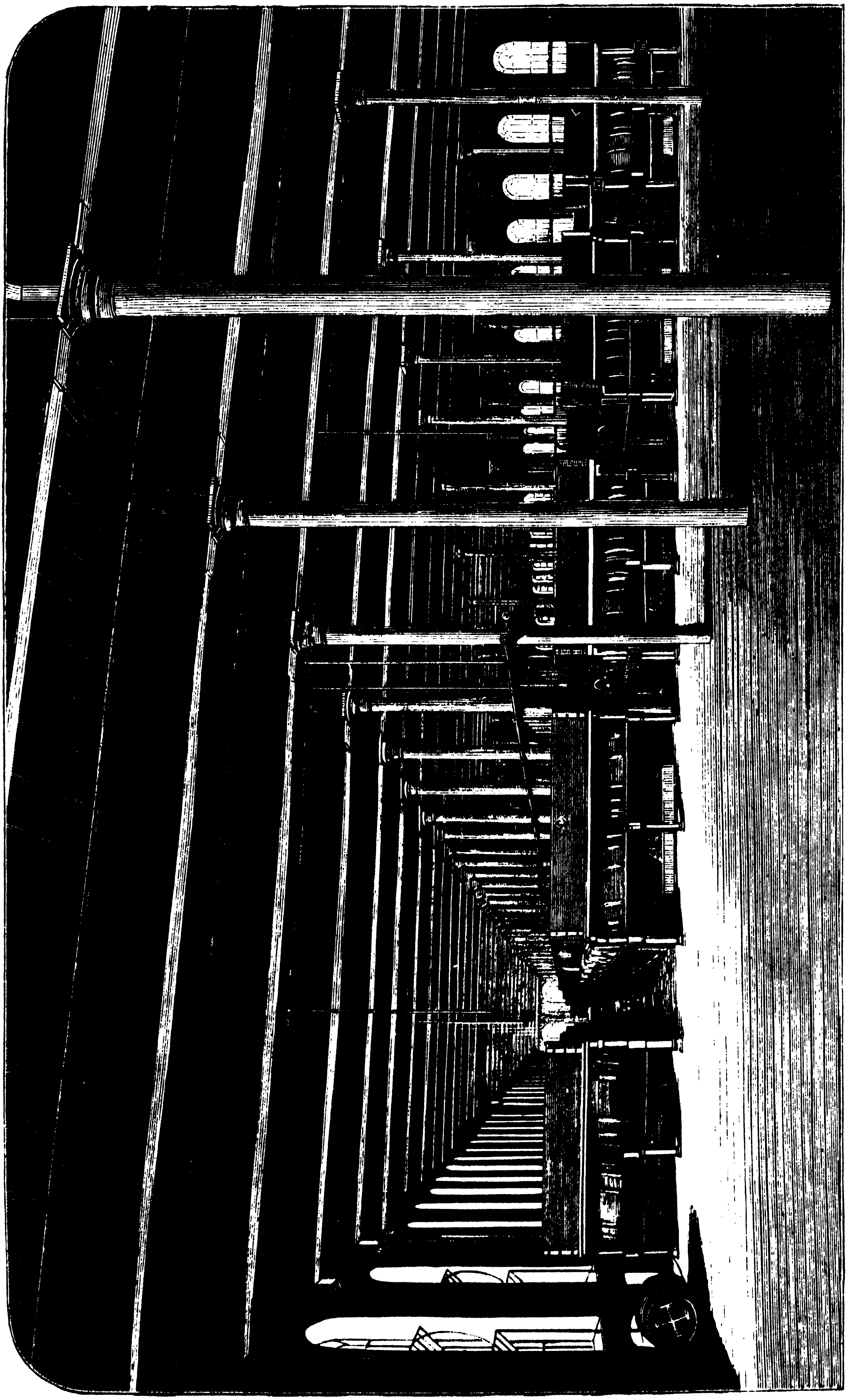
Proceedings of the Royal Institution of Great Britain.

" " Royal Society.

Monthly Notices of the Royal Astronomical Society.

NOTICE TO AUTHORS.

*** Authors of ORIGINAL PAPERS wishing REPRINTS for private circulation may have them on application to the Printers of the Journal, Messrs. W. CLOWES & SONS, 14, CHARING CROSS, S.W., at a fixed charge of 30*s*. per sheet per 100 copies, including a COLOURED WRAPPER and TITLE PAGE, *but such Reprints will not be delivered to Contributors till* ONE MONTH *after publication of the Number containing their Paper, and the Reprints must be ordered before the expiration of that period.*



Tunnery at Messrs. Allsopp & Sons' Brewery, Burton-on-Trent.

THE QUARTERLY

JOURNAL OF SCIENCE.

JULY, 1870.

I. BEER, SCIENTIFICALLY AND SOCIALLY CONSIDERED.

By James Samuelson, Editor.

During a visit which I paid last year to Germany, the Tyrol, and Switzerland, I was greatly struck with the fact that in countries where beer is the national beverage, the humbler classes are comparatively sober; whilst in those parts where wine, even the thin wine of the country, and ardent spirits usurp the place of the milder beverage, there is a nearer approximation to the habits of our own people—in other words, there is a large amount of drunkenness.

In publishing elsewhere a short account of my observations,* I ventured to express the opinion that the man who should succeed in introducing into Britain and bringing into general consumption a mild, brisk, sparkling beverage such as one gets abroad, would be a greater benefactor to his people than the most self-denying devoted advocate of teetotalism, and some of the most influential organs in the country, and notably three,† have more or less emphatically endorsed this view in their criticisms. What is still more satisfactory, I have received inquiries concerning the difference between the processes of manufacture of the English and German beer, from persons who have the will and ability to carry out my suggestion, whilst German beer is daily more sought after, and in our large towns, such as London, Manchester, and Liverpool, it may readily be procured, though the cost is rather high owing to the limited consumption. Instead, therefore, of having over-estimated the importance of the beer question, I find that it is far more deserving of consideration than I had imagined, and after having directed my attention to it, and inquired further into its scientific and social aspects, I have arrived at the conclusion that there are few subjects of greater national importance to us as Englishmen.

One of the journals to which reference has been made,‡ has gone so far as to say that "wholesome beer and wholesome recreation

* 'The German Working Man.' Longmans.

† 'The Illustrated London News,' January 1; 'The Pall Mall Gazette,' January 8; 'The Gardener's Chronicle,' March 19.

‡ 'The Pall Mall Gazette.'

are, for the most part, beyond the reach of our working men;" and although much of the blame rests with the operatives themselves, who prefer to give 6*d*. per quart for bad beer at a public-house, rather than the same price for the finest Burton ale, which they could easily procure by combination, yet it is perfectly true that a large proportion of the beer now sold to the masses is totally unfit for consumption. If any of my readers are disposed to doubt this, let them read the following paragraph which I have extracted from the proceedings of the Liverpool Select Vestry, as reported in the Liverpool 'Daily Post' of January last:—

"POISONOUS BEER AND LUNACY: A BREWER'S TESTIMONY."

"A conversation as to the cost of pauper lunatics arose, and Mr. Glover, addressing the committee, said he thought that, with regard to lunacy, they began at the wrong end. He had visited the lunatic asylums in Lancashire within the last three or four months, and he had asked the masters of the institutions what was the cause of the increase in pauper lunatics? The answer was drunkenness, and he (Mr. Glover) believed that that was the case. He thought the health committee ought to be asked to appoint some sort of an inspector to look after the quality of the drink sold. They appointed inspectors of meat and fish, and they condemned bad fruit, but bad drink was ten times worse than all of them. There was a law which, if put in force, punished people for using poisonous ingredients in the making of beer—preventing them from using grains of paradise, nux-vomica, oil of vitriol, ammonia, and other things that were used in making beer. That was in addition to malt and hops, but if only malt and hops were used there would be no lunatics from drink. His impression was that all a working man could spend in honestly brewed beer would not kill him or drive him mad, if the beer were good. There were some dishonest publicans as well as dishonest brewers; and there were some publicans who rode handsome chargers, and their wives were driven about in splendid equipages, and they were doing great injury to people and filling the workhouses. He believed the drink they sold was not honest drink, but contained some of the things he had described. When a brewer had beer that would not keep long, he said to his customer, when it got a little sour, that he would change it. It was taken back to the brewery when sour, and then the dishonest publican bought it for 10*s*. or 1*l*. a barrel. He then went to the druggist's shop, and got something that neutralized the acid; and, was not the poor creature who afterwards drank the beer likely to go mad? If a man had a pint or two of good honest beer, he would never go mad. The health committee ought to attend to the matter, and see that good beer was given to the people."

We shall presently have an opportunity to consider scientifically the character of those precious ingredients, grains of paradise, *cocculus indicus*, and other substances not mentioned by the candid brewer whose remarks I have just quoted, with which the poor man's beer is drugged; but before doing so, I propose to give a short account of the materials which ought to be used in the production of wholesome beer, of the scientific principles involved in the art of brewing, and of the most approved methods adopted at respectable breweries at home and abroad.

It would occupy too much space to enter fully into the history of beer, but it may interest some of my readers to know that its use is well authenticated in the days of ancient Rome, and according to Tacitus, the old Teutons had already acquired that taste for "Lager," which has been transmitted to their descendants in our time, for that author mentions it as their common drink. Pliny, too, states that it was consumed in Spain and Gaul, and that it was made from various kinds of grain, whilst a recent writer on the history of Burton-on-Trent,* tells us that the brewing of ale in that town is unquestionably coeval with the Abbey, it being a beverage of much repute with the Saxons, so that there can be little doubt of its having been drunk all over Europe in very early times. Mr. Molyneux, the author referred to, tells us, however, that the brewing *trade* of Burton-on-Trent is comparatively recent, and the credit of having originated it is accorded to one Benjamin Printon who lived in the early part of the last century, whilst at the close of that century there seem to have been only nine brewers in Burton, amongst whom appear the names of Bass and Worthington, but not yet that of Allsopp, whose ancestor, Mr. Benjamin Wilson, was however doing a large business in 1748.† Such of my readers as are curious on these matters, will do well to peruse Mr. Molyneux's interesting little treatise, where they will also find a variety of information concerning the geology, &c., of the Burton district: but we must now proceed to consider the materials which enter into the manufacture of beer.

Those are, or should be, water, malt (barley), hops, and yeast, and these substances possess not only a practical value for the brewer, but many special points of interest for the chemist and the student of botany. There has long been, to the uninitiated, a mystery connected with the water of Burton-on-Trent, the prevalent notion being that it is the river water which possesses some special virtue for brewing purposes. The fact is, however, that it is the spring-water of the district which is so well adapted for the manufacture of beer, and, although the effect is not yet clearly understood,

* 'Burton-on-Trent; its History, its Waters, and its Breweries.' By William Molyneux, F.G.S. Trübner and Co.

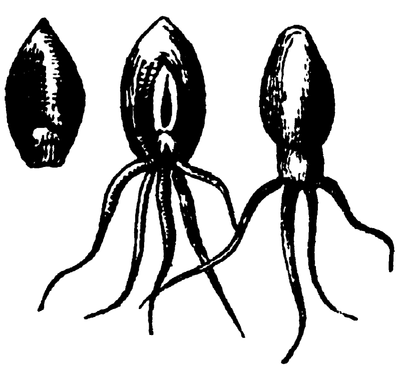
† 'Burton and its Bitter Beer.' By Dr. Bushnan. W. S. Orr and Co.

the cause has long been well known to chemists. It arises from the presence in the water of "earthy sulphates and carbonates," and the absence of organic matter which is fatal to the brewing process. Analysis has shown the Burton water to contain nearly 19 grains of sulphate and 15 grains of carbonate of lime to the imperial gallon (besides sulphates of potassa and magnesia), and the theory is that these alkalies combine with the acid of the malt extract, and, in the form of insoluble salts, are precipitated and carry down with them the nitrogenous substances which it is desirable to get rid of in the brewing process; so, for the same reason that the presence of salts of lime and potash in the Burton water is advantageous, that of organic matter would be injurious, and the freedom of the water from the latter is therefore very advantageous to the brewer. Should any of my readers desire further information on this subject for practical purposes, they may obtain it in the able article on "Beer," in Dr. Muspratt's 'Dictionary of Chemistry,' or in those on the same subject in Ure's 'Dictionary of Arts,' and Watts's 'Dictionary of Chemistry;' while Mr. Molyneux's work, already named, also contains an excellent chapter on the "Waters of Burton," and the effect upon them of the strata through which they percolate.

Malt, as every one knows, is barley steeped and dried. There are various kinds of malt, known as pale, amber, brown, and black, of which the first-named is employed in brewing pale ale, and the last (which is roasted like coffee) is used for colouring porter. Barley undergoes two kinds of change during its conversion into malt, the one morphological, that is to say, in its plant life, the other chemical. In order to effect the conversion it is steeped for two or three days in water, then spread out upon a floor to germinate, and when it has sprouted to a certain length it is taken to the kiln to dry, and in the subsequent handling "the radicles" which have shot forth during germination, are broken off and the grain assumes to a great extent its original appearance. The annexed woodcuts will render the morphological change apparent to the eye; Fig. 1 being a grain of barley with the husk removed to show the embryo; Figs. 2 and 3 the same after germination.*

FIGS.

1. 2. 3.



But a chemical change, not so easily understood, also takes place in the malting process, and I will endeavour in a few sentences to make it as clear as possible. For our purposes, the barley may

* These woodcuts, and some others in this article, have been copied, with the permission of the publishers, from the plates in a beautiful and interesting volume 'On Strong Drink and Tobacco Smoke,' by the late H. P. Prescott, F.L.S., just published by Messrs. Macmillan and Co. Frequent references will be made to this work. Mr. Prescott died recently of consumption, and his book has been passed through the press, and edited, with much good feeling, by Professor Huxley.

be said to be composed of two main constituents, albumen and starch, and during the germinating process the albumen is converted into a new substance, diastase, so called from its property of being able to split up the other constituent of the grain, starch, into dextrin or gum, and sugar. The object of this chemical change in *nature* is to supply the embryo of the plant with a soluble pabulum or nutriment; but as in malting the germination is arrested at an early stage, the starch is converted into soluble gum and sugar, merely to be extracted in the mashing process which follows at the brewery. The result of this extraction is to produce the "worts," or "wort," the stock, so to speak, of the beer.

The morphological changes which take place in the growth of the barley, either during germination or subsequently, are deeply interesting, and an illustrated account of them will be found in Mr. Prescott's work referred to, whilst a detailed description of the chemical changes to which the grain is subject is contained in the various articles on "Beer" (more especially Dr. Muspratt's) in the Dictionaries already quoted. These are, however, beside our purpose, and we must now pass on to the other materials used in brewing, namely, hops and yeast, both of which are as interesting as malt to the chemist and botanist.

The hop-plant belongs to the same botanical group as the stinging nettle (*Urticaceæ*) and is cultivated chiefly in the counties of Kent, Sussex, Surrey, Worcester, and Hereford, and also imported from the Continent. The bitter principle which it contains, and which is extracted in the boiling process of the brewer, is called "*lupulite*," and it is found in the fruit, which is so well known as hardly to need description. For the guidance of my readers, however, I will extract a short account of it from Mr. Prescott's work, accompanied by such of the figures as seem essential:—

"The fruit of the plant," he says on p. 40, "(technically called *strobilæ*), which is so largely used in brewing, consists of a series of delicate green, semi-transparent bracts, attached to a common stalk (Fig. 4) and overlapping at their edges in a very elegant manner. The seeds are minute, flattened, conical berries of a light-brown colour; they are attached to the bases of the bracts (Fig. 5) which fold over at their lower edges to afford them additional support, and each inner seed-containing bract is covered by another externally. Attached to the outer seed-coat is a beautiful transparent membrane, and on this lie, in countless numbers, minute golden-coloured oval bodies which are the *lupulite* so valuable to the brewer (Fig. 6). These granules are abundant on the bracts, especially at their bases, where the seed is lodged; they are also present in large quantities on the leaves of the plant. When one of these granules is placed in water under the microscope, and a drop of sulphuric or nitric acid is added, it immediately bursts, and the

coloured matter discharged is seen to consist of excessively minute, somewhat spherical, particles of an oily nature, that move freely and

Fig. 4.

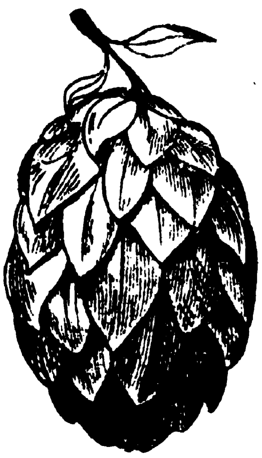


Fig. 6.

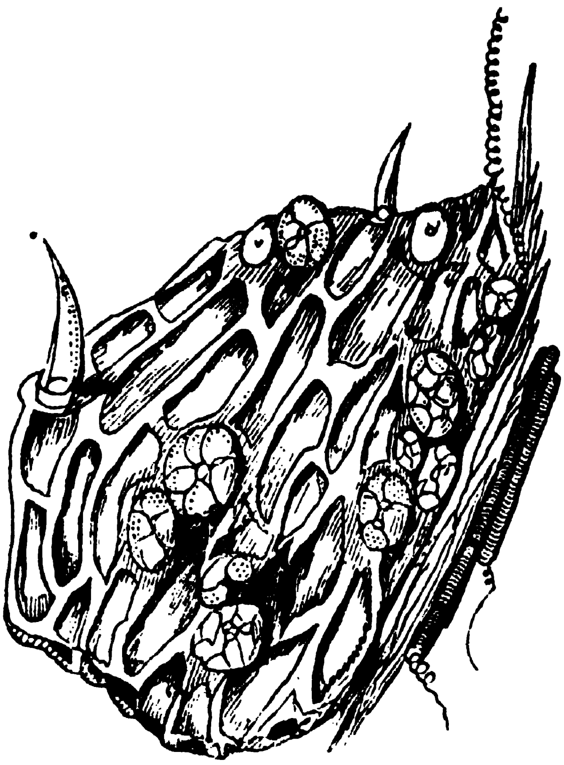
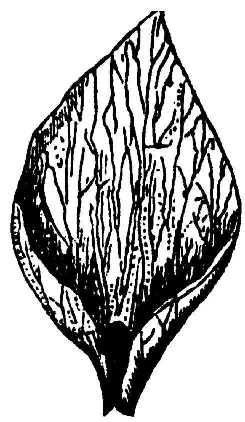


Fig. 5.



with great rapidity amongst each other with a tremulous motion. This peculiar motion may at times be observed in the contents of the granules before they are broken." * * * "A common practice amongst hop-buyers is to take a small quantity of the dried hop-fruit, place it in the palm of one hand, and with three or four knuckles of the other, to chafe and bruise it. The value of the sample is judged of by the aroma it emits and the sticky almost resinous stains left upon the hand. This is a rough but effective way of judging both of the number and produce of the *lupulite* granules by crushing them. Good sound hops will yield about one-sixth part of their weight of these grains. Analyzed by the chemist they are found to contain, besides a volatile oil, no fewer than thirteen substances, more or less in combination with each other. But it would appear that to the volatile oil, soluble in water and alcohol, and the bitter principle, *lupulite,* the most valuable properties of the fruit are due."

I have made this somewhat lengthy extract from Mr. Prescott's book for a twofold reason; first, because it conveys in brief and clear terms all that is interesting to us, in this portion of the subject, and secondly, because I consider that his powers of observation and his practical researches deserve to be prominently noticed. In another part of his book he tells us that he examined the spent hops of breweries and found that not more than one-half their *lupulite* is made available, a circumstance which shows how necessary it is to call into requisition, more largely, the services of scientific men, even in our most commonplace manufacturing processes.

Yeast is a lowly unicellar plant called *Torula cerevisiæ.* The growth of its cells (which on examination with the microscope are found to contain minute nuclei) has been ably described * by an eminent botanist (Dr. Henfry), who obtained some fresh wort in which fermentation had commenced and placed a drop of the liquid under the microscope. At first, he says, these globules enlarged until they attained a certain size, and then they remained unchanged for a time. Next, a little point-like bud was seen to project from one portion of the cell-wall, and this grew until it attained the same size as the parent cell. This occupied about three hours, and by a repetition of the process sixteen cells were developed from a single one. After a time the growth slackened and at length it ceased, the observer believed, "undoubtedly because all was removed from the liquid which could serve for their growth." The following woodcuts represent the microscopical appearance of the cells of the yeast fungus, Fig. 7 being that found at the bottom, and Fig. 8 a "white mealy substance," at the top of the liquid; the growing globules will be seen in the former, from which my microscopical readers will perceive that the plant multiplies by the well-known but incomplete process of fission.

FIG. 7.

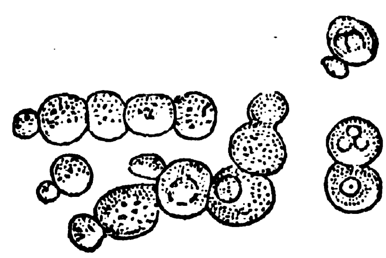
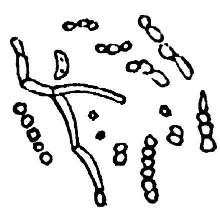


FIG. 8.



These, then, are the materials which should be employed in the brewing of good ale. Water, free from organic matter and containing sulphate and carbonate of lime; barley, in the form of malt; hops, and yeast; and although the reader will have gathered from the preceding short account of these substances, what leading principles are involved in their use and treatment, I propose briefly to recapitulate the changes which occur in the brewing process, before attempting to describe the practical operation. In the malting or germination of the barley the albumen in the grain becomes converted into diastase, the property of which is to change the *starch* (also constituent in the barley) into soluble dextrin or *gum*, and *sugar*, and consequently the malt possesses a sweet taste which is not present in the grain previous to malting. In the mashing process, this sweet substance is washed out of the malt, and with the water employed for the purpose goes to form the "*wort*," or stock of the beer. This "wort" is subsequently boiled with *hops*, which contain a bitter principle, *lupulite*, and an *essential oil*, of which the effect is to impart a bitter aromatic flavour to the beer, at the same time as the chief *organic* constituents of the *wort* are removed. And finally through the introduction of yeast, a minute

* 'Micrographic Dictionary' (article "Yeast-Plant"), from which, with the publisher's permission, the woodcuts are copied.

plant, the cells of which multiply with incredible rapidity, *fermentation* is set up, the chemical effect of which is to convert the *sugar* contained in the "wort," into *carbonic acid* and *alcohol.*

The brewer takes care, however, to stop the fermentation at a certain stage, so that a portion of the sugar may remain unconverted, and the chemical change is then completed in the cask or bottle, the carbonic acid being held in solution until the beer is drawn or otherwise exposed to atmospheric action. This gives to good beer its brisk sparkling appearance and puts a *head* upon it: in no case is the effect so conspicuous as in the *bottled* German beer and English and Scotch pale ales, which continue to effervesce and sparkle like champagne, long after the liquid is poured into a tumbler.

Passing now from the theory to the practice of brewing, I propose to conduct my readers through some portions of the magnificent establishment of Messrs. Allsopp and Sons, of Burton-on-Trent, where all that science and skill can accomplish has been done to perfect the process. Let us commence with the malting; and the reader must imagine himself in a large chamber (one of several devoted to this purpose), one end of which is partitioned off for the steeping process. This side of the room, which forms an elongated trough, is divided into squares, and partly floored with a number of perforated tiles, which serve to drain off the water; and when the barley is sufficiently steeped, it is turned out upon the chamber floor, close to the trough. Here it is kept within certain limits, by means of a removable partition consisting of boards, which can be fixed between the columns that run across the chamber parallel to the steeping-trough, or removed at pleasure; and the barley is then said to be in the "couch," where it is gauged by the Excise. After gauging, the partitions are removed and the steeped barley is spread evenly over the chamber floor to germinate: the germination having reached the proper stage (as already described), it is conveyed to the kiln to dry. But at Allsopps' the transfer of the barley from the germinating floor to the kiln is only the passage from one chamber to another immediately adjoining; and unless his attention is directed to the floor, the uninitiated visitor would observe nothing in this second chamber to denote its function. The floor is paved with perforated tiles, and in the kiln pit underneath, which is the same size as the upper chamber, there stand a series of open furnaces, or gigantic braziers, in which coke fires are lighted when the kiln is in use. Over the fires there is a contrivance called a disperser, by which the heat rising from these furnaces is equalized over the whole surface; and when the spectator looks up at this disperser, he perceives plainly the perforations in the tiles of the kiln floor above, and which allow the heat to penetrate to the malt. After kiln-drying, the barley, or as it is then called, malt, is subjected to one more process, namely, screening. This consists in allowing it to run over an ob-

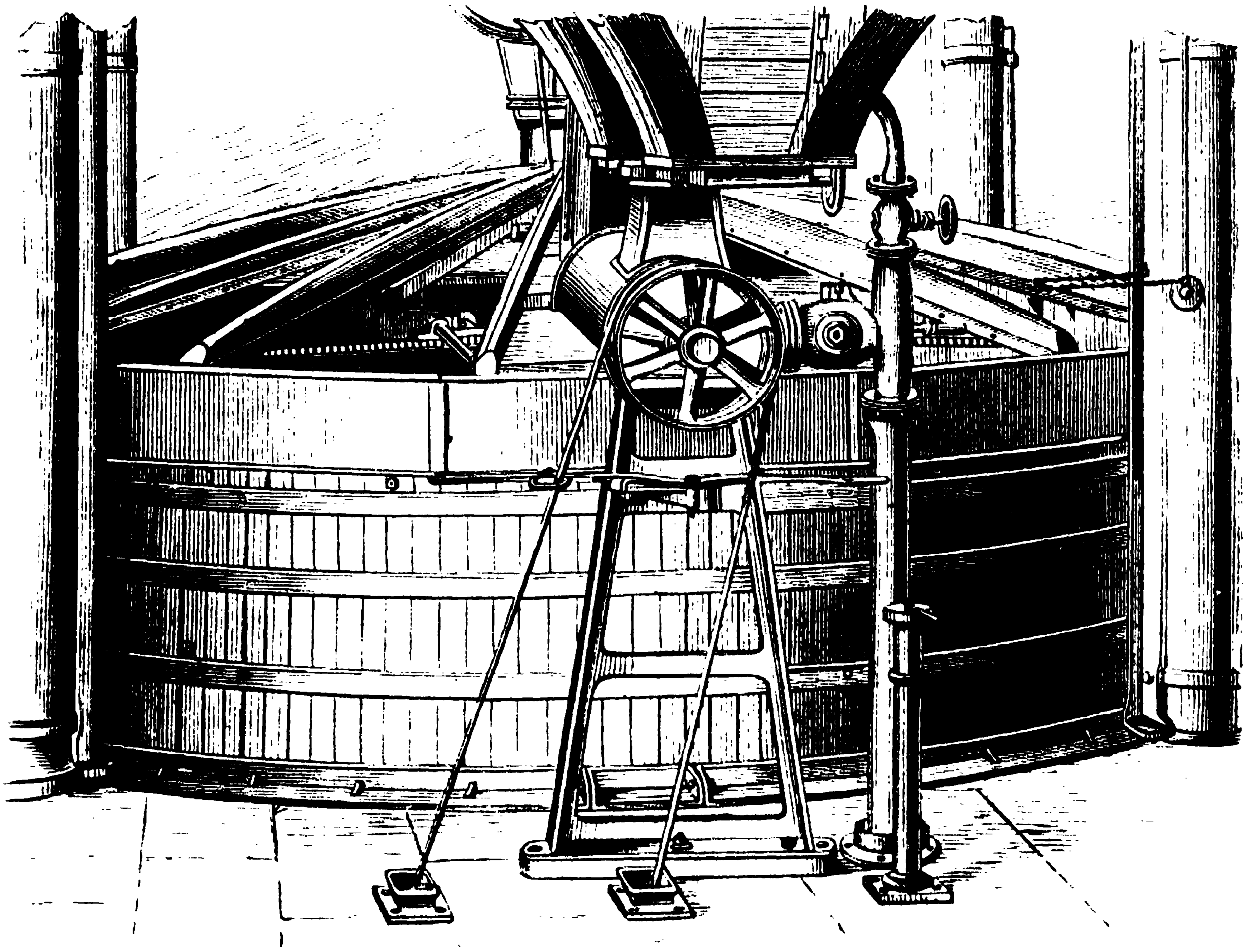


Fig. 1.—Mash Tun (Closed).

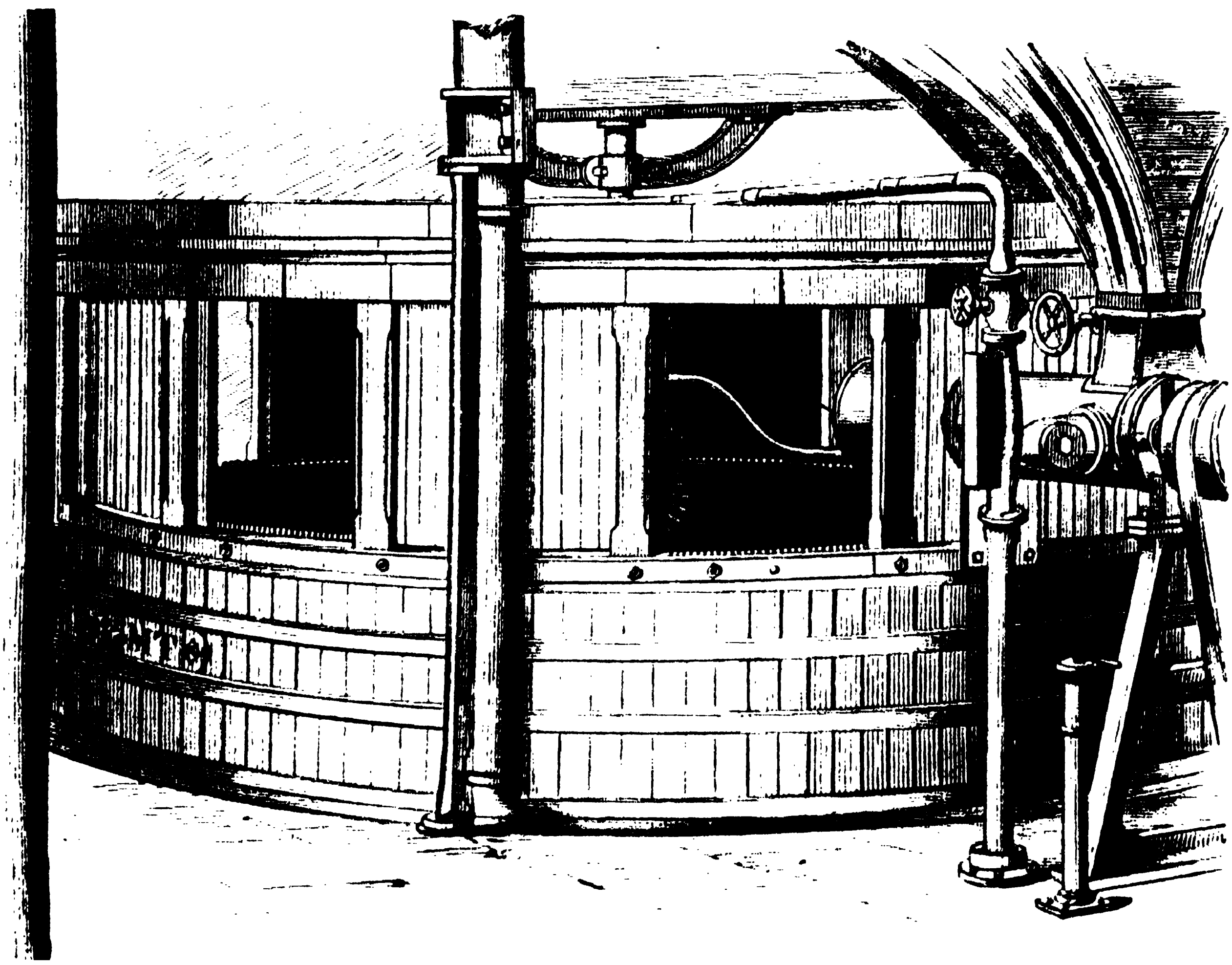
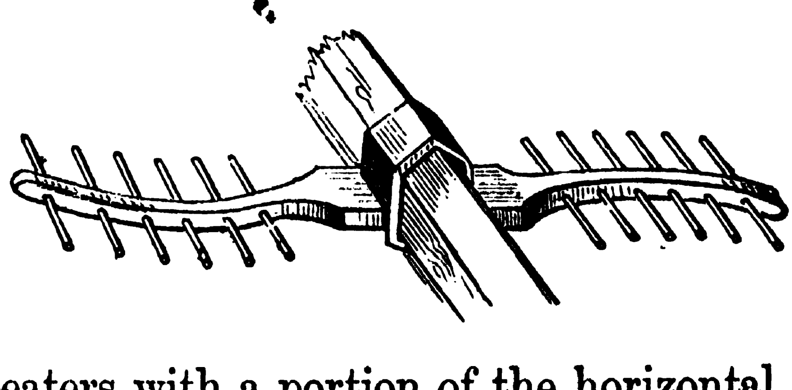


Fig. 2.—Mash Tun (Open—"showing the Sparge").

lique screen, and during its passage the malt dust and radicles are removed. These make an excellent food for cattle, varying in value from 5*l.* to 7*l.* per ton, according to the requirements of the season.

This completes the malting process; and now we pass on to the brewing, which commences with the *grinding of the malt.* By means of a "Jacob's ladder," it is conveyed to an upper story, and there allowed to fall into a hopper, which feeds a pair of smooth rollers, very similar to those used in an oil mill for rolling linseed. Being thus split, and partially ground, it is carried along the chamber floor by means of an Archimedian screw, and passed through a hole in the floor into a large hopper in the story below. This hopper is fixed above the "mash-tun," or "mash-tub," where the ground malt is mixed with water at a temperature of 170° to 180°, and undergoes the *mashing* process. The room in which we are now supposed to stand contains eight such tubs, each capable of treating fifty quarters of malt, and two of them are shown in Plate II., the one closed and the other open. I was, unfortunately, unable to obtain a sketch, which would fully illustrate the mashing process, but will endeavour to make it as clear as possible with the means at my command.* The mash-tun has a false bottom, composed of radiating sections, the object of this being to take them out to clean after each mashing. Then there revolve in the tub two kinds of apparatus, the one for "mashing," the other for "sparging," to be explained presently. An upright spindle revolves in the centre of the tun; and rotating with it, is a strong horizontal wooden pole, having one end affixed to the central spindle, and the other end, to which a cog-wheel is attached, resting upon rack-work that runs completely round the inside of the tun. The arrangement will be better understood if the reader pictures to himself one of those "roundabouts," on which children ride at fairs, with the horizontal pole resting on rack-work, which is visible in the plate. Along the rotating *horizontal* pole there are placed several beaters, somewhat resembling the rakes upon a reaping machine, but armed with teeth on either side. I have sketched (Fig. 9)

FIG. 9.



one of these beaters with a portion of the horizontal pole, and by a suitable mechanism the beaters are made to revolve *vertically* in the

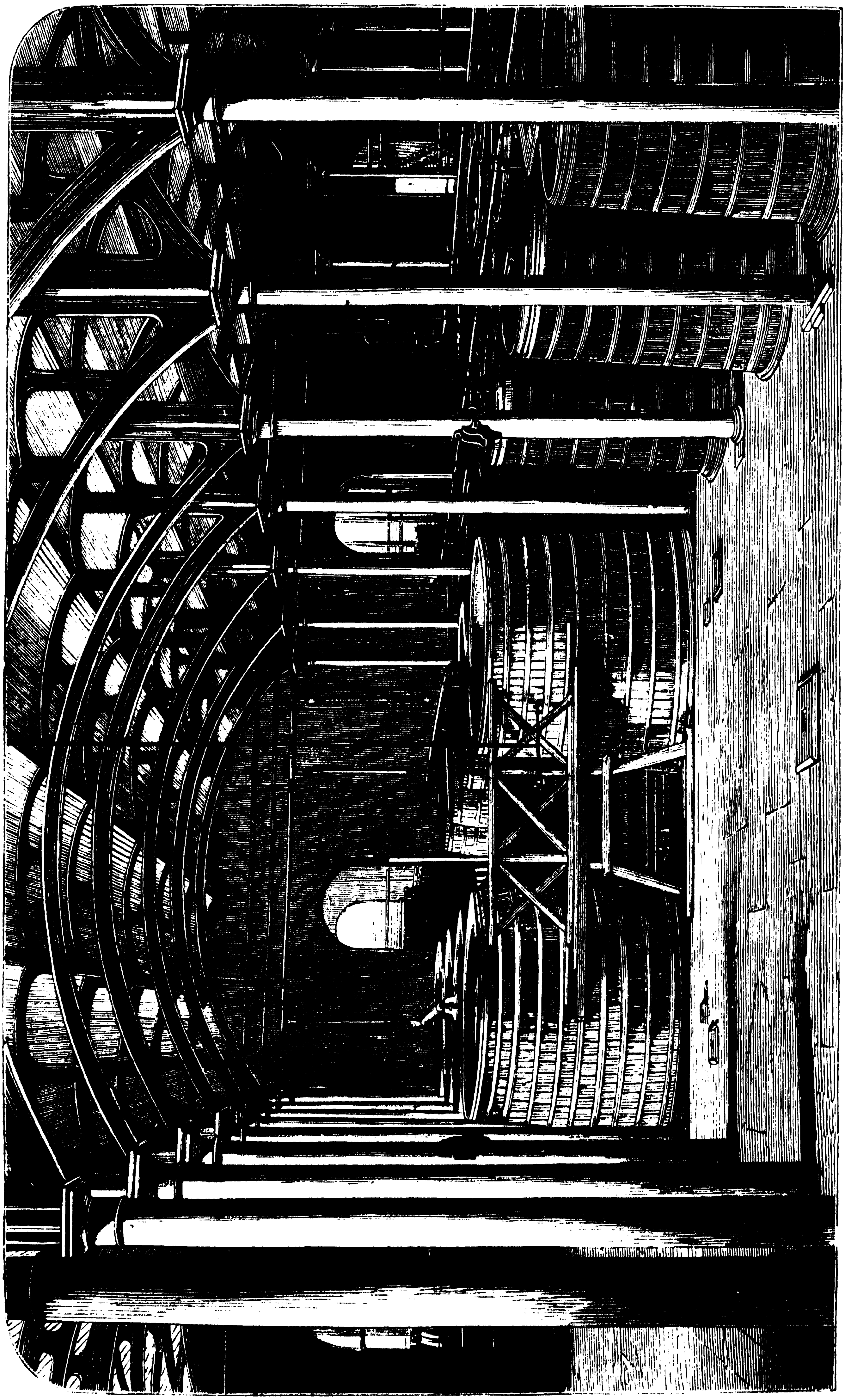
* All the page plates are copied from photographs kindly lent me by the Messrs. Allsopp.

mash, whilst the pole to which they are attached rotates *horizontally*, so that the whole contents of the tun are thoroughly beaten and mixed. This operation has really a very novel and interesting appearance to one who has never witnessed it before. As the observer stands looking into one of the openings in the mash-tun, nothing appears to be going on in the mash so long as the beaters are on the side opposite to him, but presently a slight undulation of the surface announces their approach. Slowly the pole, with its beaters, moves round towards the side where the spectator stands; the undulations become more marked, until at length the revolving arms make their appearance, breaking up the surface and creating a great commotion. After the round is completed, the apparatus is stopped, and the mash is left undisturbed for some time, the process being repeated at regular intervals. But there is another rotating apparatus of a very simple kind attached to the central spindle, and that resembles in appearance and action the horizontal discharge-pipe at the back of a watering cart. It is in fact a copper pipe, of a suitable shape, with holes drilled along its whole length, and may be seen on looking through one of the openings in the mash-tun (see Plate II.). After the strongest portion of the "wort" is obtained from the malt by the mashing process already described, it is dosed with a shower of hot water, poured upon it from this rotating pipe, which is called the "sparge," the operation being termed "sparging." At the bottom of each mash-tun there are four pipes through which the wort is drawn off, and these pipes lead into a main which conducts the liquid into the "underback," an intermediate vessel between the mash-tun and the boiling copper, where, as the name indicates, the process of *boiling* with hops is carried on.

The boiler is an open copper cauldron or kettle, set in brick, and heated from beneath. It has a capacity of about seventy barrels; and when the requisite quantity of hops is deposited in it, the wort is admitted through a pipe connected with the "underback," into which the liquor has been run from the mash-tun, as already described. The feed-pipe bends over the opening of the copper, whilst at the bottom of the same vessel is another pipe, through which, when the boiling is complete (and the liquor is well stirred during the process), the boiled wort, or unfermented beer, is run off into the "*hop-backs.*" These, again, are intermediate vessels, square wooden cisterns, with false bottoms, which act as a sieve, and the object of running the liquor into them is to free it from the spent hops with which it is accompanied, before cooling and fermentation.

A word concerning the spent hops. After the liquor has been allowed to drain from them in the hop-backs, they are placed in hydraulic presses to extract any wort that may still remain in them, and are then packed and sold as manure.

From the "hop-backs" the wort runs into the *refrigerators*,



Fermenting Room at Messrs. Allsopps' Brewery.

of which there are two or three descriptions, some of them occupying the floors of enormous chambers, which are moreover open to the external atmosphere through the peculiar construction of the windows. The principle of these refrigerators is, however, always the same, the hot wort being allowed to flow over a series of tubes through which cold water freely circulates. Sometimes the tubes form a spiral coil, at others they run in parallel rows, covering the entire floor of the chamber, but in every case they slope in an inclined plane, so that when the wort is poured on at the higher end it flows down slowly to the lower, becoming cooled in its passage. In winter the cold air, which is admitted on all sides into the cooling chamber, suffices to reduce the temperature of the wort in its passage down the inclined plane, but in summer it is necessary that the water which flows through the pipes should be made as cold as possible; and at Messrs. Allsopp's, water is cooled on a large scale for this purpose by the evaporation of ether. This is done outside of the main building, and the water thus cooled is conducted all over the brewery, not only into the wort-refrigerators, but wherever a low temperature is found requisite in the brewing process.

From the coolers the wort is next conveyed into the "fermenting rounds," capacious vessels, each holding from 15 to 90 barrels, and an idea may be formed of the magnitude of the operations carried on at Allsopps', when it is mentioned that the new brewery (there are two) has two fermenting rooms, each containing 136 such vessels, consequently above 4000 barrels of beer may be fermented at one time. Plate III. represents a portion of one of these fermenting chambers. The principle involved in *fermentation* has already been described, as the conversion of the saccharine matter in the wort into carbonic acid and alcohol. As my readers are no doubt well aware, it is effected by adding to the wort a quantity of fresh yeast from a previous brewing, and such an amount of carbonic acid gas is generated that the invisible gas occupies the whole space between the surface of the fermenting liquor and the rim of the vessel. A very curious effect shown to visitors is to pass a hat through the apparently empty space over the liquor in the fermenting vessel. This hat at once fills with the invisible gas, which may then be poured into another belonging to a visitor, just as we see chemical lecturers illustrate the specific gravity of the carbonic acid gas they have been making, by pouring it from one glass vessel to another.

Let me, in passing, refer to the method in which, at Messrs. Allsopp's, the superfluous yeast is utilized, for it is only at these large establishments that every waste product is turned to good account. First, as much of the ale as possible is allowed to drain from the yeast, and then it is press-packed. The soft yeast is placed between suitable cloths and transferred to hydraulic presses

of low power, which reduce it to pretty much the same consistency as the imported Dutch yeast. In this condition it is packed and exported to France for distilling purposes.

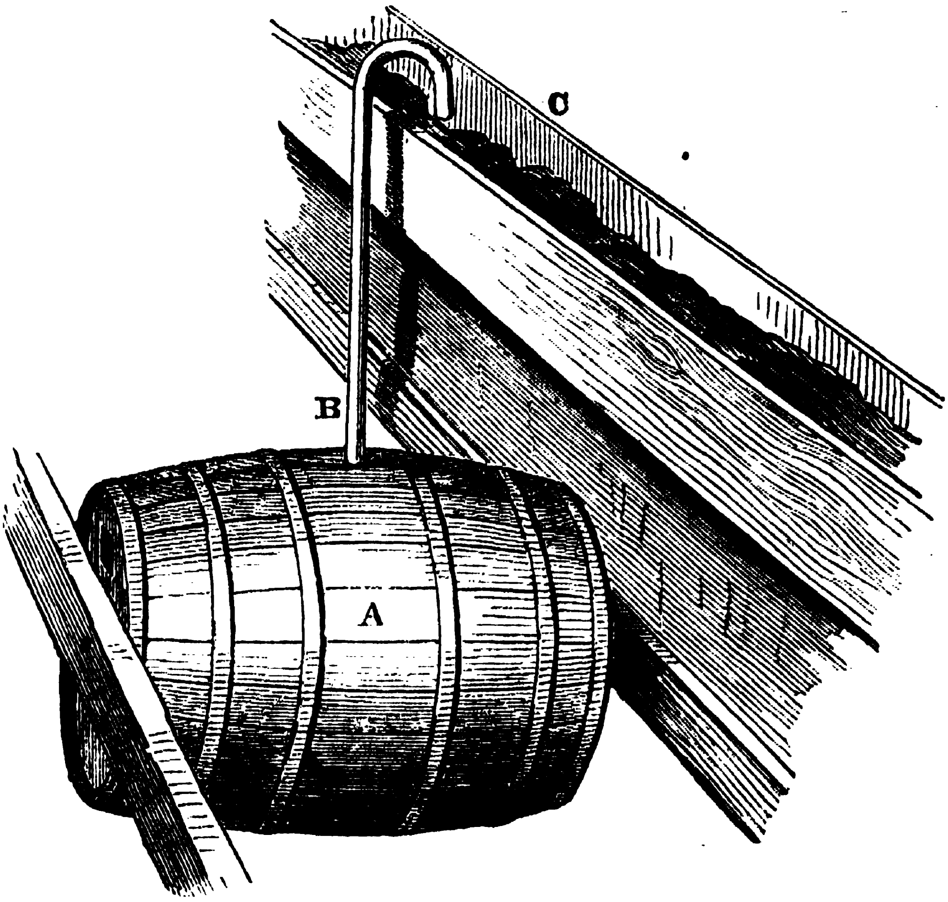
The rationale of the fermenting process is not as yet thoroughly understood, but it is known that the surface yeast is formed by the nitrogenous matter contained in the wort being carried upwards by the bubbles of the generated carbonic acid gas. When this fermentation is carried on at a temperature of from 65° to 90° Fahrenheit, as it is almost always in England, the yeast invariably rises, and in Germany this is called "Obergährung," or top-fermentation; but in Bavaria and elsewhere abroad, the fermenting process is often carried on at a lower temperature, and then it is called "Untergährung," or "bottom fermentation," for in that case the yeast does not rise, but the nitrogenous matter sinks to the bottom and forms a slimy sediment. This is the essential difference between the Continental and English methods of brewing; except perhaps that abroad a larger portion of saccharine matter is left in the beer, which, under a cool temperature is gradually converted into carbonic acid and alcohol in the vessels into which it is subsequently conducted or poured, and the result is a rich effervescing beverage. I am indebted to my friend Mr. Fenton, the Secretary of our Embassy at Munich, for some interesting particulars concerning the method of brewing in that city. "Obergährung," or "top-fermentation," is there conducted at 15° to 17° Reaumur = 66° to 71° Fahrenheit, and "Untergährung," or bottom fermentation, at 12° R. = 59° F. The process is not carried on as with us on the floors of the brewery, but in specially constructed subterranean chambers ("Gährkammer") in which the temperature is kept low by means of ice, and thence the beer is conducted by pipes into the vessels in which the fermentation is completed.*

In England, as abroad, in the best breweries, the beer is conducted after fermentation into barrels specially constructed for the purpose, in which the fermenting process is completed. This at Allsopps' and other large breweries is called the "Union" system, long rows of barrels being connected together by a horizontal pipe. The barrels are raised above the floor, suspended in a frame, and are made to revolve on their axis precisely the same as a revolving barrel-churn. The chamber in which they are placed is called the "Union-room," or tunnery, and the reader will form a fair idea of its extent and appearance by referring to the Plate (I.). There are two rows of barrels as shown in the

* The German system of mashing is also entirely different from the English. I believe that the best book published abroad on the Continental system of brewing is 'Die Bierbrauerei,' by Heiss, published at Augsburg, 5th edition, 1869, price 5 florins; but I was unable to procure it in time for the preparation of this essay.

Plate, and above and between the rows runs a long tank, in which the superfluous yeast is collected. This is done by means of a "swan-neck" pipe, a syphon acting inversely, and the arrangement will be understood from the following woodcut (Fig. 10), where A

FIG. 10.



is one of the barrels containing the incompletely fermented beer, B the swan-neck, C a portion of the long tank or receptacle for the yeast (Fig. 10). The latter continues to rise slowly whilst the beer remains in the barrel, being carried upwards (as during active fermentation) by the escaping carbonic acid gas, and having risen into the "swan-neck," it may be seen slowly bubbling over into the tank. The temperature of the beer during this process is regulated by a flow of water through an ingeniously contrived tubular apparatus, which can be inserted into or withdrawn at pleasure from the barrel, through an oblong aperture in front (see Fig. 10); and when the beer is cleared of the remaining impurities it is drawn off by boys who creep underneath the barrels and open a tap attached to a pipe, first into large vats and then into casks for sale. The object of allowing the barrels in which fermentation is completed to revolve, is simply that they may be cleansed after each operation.

It has, of course, been impossible for me within the short limits of an essay, professing to deal with the social as well as the scientific aspects of this question, to describe fully either the principles or practice of brewing; but I hope enough has been said to convey to the reader a fair idea of both; and there now remain to be con-

sidered: 1st, how beer is injuriously affected during or subsequent to its manufacture; and 2nd, what social results follow from its adulteration or abuse. Those who have mixed much with artisans know well that they seldom drink the fine Burton ale, and if they do, it is often adulterated after it leaves the brewery; but with a view to ascertain what they really do drink, I have obtained from my friend Mr. Norman Tate, F.C.S., Analytical Chemist of Liverpool, who has interested himself deeply in this question, a report upon the Liverpool beer, which is as follows:—

"The results of the examination of twenty-five samples of beer of the kinds known as 'sixpenny,' and 'eightpenny,' purchased in the ordinary way from public-houses in different parts of Liverpool, showed that the quantity of alcohol varied in these samples from 2·2 per cent. (by weight) to 5·62 per cent., the percentage in fourteen specimens being under 4, very little difference being observable in this respect between the sixpenny and eightpenny. The general results convinced me that fully half the samples were not genuine preparations of malt and hops. One undoubtedly contained *tobacco;* another, of a dark colour and rather hard unpleasant taste, gave unmistakable evidence of the presence of *sulphate of iron;* whilst two others contained such a quantity of *common salt* as could not be accounted for by the presence of that ingredient in the water used for brewing, or by any other ordinary cause. *Sugar* also appeared to have been added in one case, and in another *carbonate of soda.* I did not find in any of these specimens indications of *cocculus indicus*, or picric acid, said to be frequently used for adulterating beer (I have found picrotoxin, the active principle of *cocculus indicus* on a previous occasion), but that other matters, such as liquorice, gentian, and other drugs, not of an injurious character, but nevertheless adulterants, were present I have not the least doubt. Several of the samples were of an objectionable character owing to bad brewing or bad keeping, and, in one or two instances, the quality was so bad that it is difficult to imagine how any persons can be found to drink such vile stuff. Only eleven out of the twenty-five were of what I consider really good quality. One of these was a sample which I purposely obtained, knowing it to be brewed by a leading firm at Burton, and to have been kept with great care by the person from whom I procured it.

"With regard to bitter beers I obtained somewhat better results, so far as general quality is concerned, with the exception, however, that the use of other bitters than hops seemed to be rather the rule than the exception. Although it is difficult or even impossible always to detect these bitters by distinct chemical tests, yet my experience of such drugs has made me so familiar with their taste that I have no hesitation in saying that quassia, wormwood, gentian, rue, camomile, and orange-peel had been used. Quassia

and wormwood, however, seemed to me to be the bitters in most general use, the quantity of the latter in one case being so great as to make the beer positively nauseous. One sample, which appeared to me to be flavoured with orange-peel, possessed a warm, somewhat spicy taste, which was very apparent in the residue after evaporation, indicating the addition of something more than the ordinary ingredients."

This report, it will be seen, affords experimental confirmation of what was said by Mr. Glover at the Liverpool Workhouse meeting, and it will therefore be interesting to inquire a little further into the matter. Our authorities tell us that the following substances are employed to adulterate beer. "*Cocculus indicus multum* (an extract of *cocculus indicus*), colouring, honey, hartshorn-shavings, Spanish juice, orange-powder, ginger, grains of paradise, quassia, liquorice, carraway seeds, copperas, capsicum, mixed drugs." These, we are told, "were seized at different breweries in London, and at brewers' druggists' laboratories."* In addition, sulphuric acid, alum, salt, *Datura stramonium*, picric acid, and other substances are mentioned by different writers.

Of *Datura stramonium* Mr. Prescott says,† "It has been frequently used by desperate characters for hocussing or stupefying the intended victim of a robbery by surreptitiously adding it to his beer at the public-house bar. It is the seed of the Thorn-apple, a native of Greece, and belongs to the same family as the tobacco-plant." The same author also describes very minutely the microscopical structure of the various seeds which ought, and which ought not, to be used in the preparation of beer, including barley, hops, *cocculus indicus*, grains of paradise, and *Datura stramonium*, his object being to facilitate the detection of fraud and crime; and I would recommend my microscopical readers, who take an interest in the question, to examine these various substances with the aid of a microscope and Mr. Prescott's beautiful diagrams.

Of the various adulterants named, sulphate of iron, alum, and salt are employed to give beer a "head" or froth (salt to stimulate the thirst as well); sulphuric acid is used to "bring it forward," or harden it, and impart to new beer the character of old; carbonate of soda to neutralize acidity; whilst *cocculus indicus*, quassia, wormwood, grains of paradise, and similar substances are mixed with beer either to impart bitterness or pungency, and to disguise the true character of the drink.

The necessity for all this doctoring has already been touched upon, but it may be as well to explain its cause more fully. At Allsopps' and other large Burton breweries (and no doubt in many

* 'Report of Committee of the House of Commons.' See Watts's 'Dictionary of Chemistry,' vol. i., p. 537.

† 'Strong Drink and Tobacco Smoke,' p. 37.

smaller respectable country breweries) the capital embarked in the trade is large enough to admit of the beer being perfectly fermented and freed from impurities or substances likely to cause acetification; the beautiful system employed by Messrs. Allsopp for that purpose has been described. But many brewers really sell their beer, not at the brewery, but in their own public-houses, and they have not sufficient capital (or it may be they are too anxious to make money) to give their products sufficient time to become fit for consumption. The beer is sometimes drawn off from the fermenting vats into the barrels in which it is to be sent out, with the bung holes open for the escape of superfluous yeast; as little time as possible is given for it to "fine," and it is sent out to the public-house with orders to return any that is unconsumed when it begins to turn sour. I do not pretend to be initiated into the mysteries of "brewers' druggists' laboratories," nor the secrets of those who employ their fraudulent compounds; but certain it is, that carbonate of soda is used to neutralize the acidity of the spoiled beer, and various drugs and chemicals are then added to impart to it an artificial flavour and counteract the alkaline taste, until, as Mr. Tate remarks, it is "difficult to imagine how any persons can be found to drink such vile stuff." But when we remember that three-fourths of the persons who do drink it are drunk already, the mystery is solved. Not only are the lower kinds of beer thus doctored, but they are often mixed with Allsopps', Bass's, and other fine ales, so that it is the interest of those firms not only to suppress adulteration, but to do their best to assist in providing the humbler classes with a cheap pure beverage, which it will not pay the vendors to sophisticate.

So far, repressive legislation has been a dead letter; we hear now and then of the Act of Victoria 23 & 24, c. 84, being put in force to prevent the sale of grossly adulterated food, or tea, but although brewers will tell us that the Excise would punish adulteration severely, I do not recollect ever having noticed a prosecution. Public analysts may be appointed under this Act, and it is to be hoped that the time is not far distant when this course will be adopted, and the doctoring of what is really the staple beverage of our people may be reduced to a minimum, if not entirely prevented.

But we have another question to consider in connection with the effects of beer upon our population, and that is its real or reputed strength. For this purpose I have compiled the following table, partly from the Dictionary articles referred to, and partly from analyses made for me by chemical friends.

A glance at this table and a moment's reflection will show why English beer-drinkers are so often drunkards, whilst Germans, who indulge in a similar beverage to the same extent, are comparatively sober. It may be safely said that the percentage of alcohol in German

beer is on the average half as great as in the English, so that where an Englishman drinks a pint, a German may partake of a quart; but when we look at the character of the beer drunk by the intemperate classes in England, and compare it with that of the poorer people abroad, we may unhesitatingly assert that less injury

Name of Beer.	Percentage of			
	Alcohol.	Malt Extract.	Carbonic Acid.	Water.
Strong Scotch Ale	8·5	10·9	0·15	80·45
Burton Ale	5·9	14·5	..	79·6
Barclay's London Porter	5·4	6·0	0·16	88·44
Dreher's Vienna Beer*	4·62	..	..	..
Low Brussels Beer (Faro)	4·9	2·9	0·2	92·0
Bavarian Draught Beer	3·8	5·8	0·14	90·26
Sweet Bohemian Beer (Prague) ..	3·9	10·9	..	85·2
Liverpool Doctored Beer (Mr. Tate's test)	2·2	..	..	..
Berlin White Beer	1·9	5·7	0·6	91·8
Sweet Brunswick Beer (Mum)	1·9	45·0	..	53·1

would arise from drinking half-a-gallon of German beer than from a pint of English ale. And again, when we compare the Berlin "Weissbier," which contains 1·9 per cent. of alcohol, with the lowest Liverpool beer, which Mr. Tate found to contain only 2·2 per cent., and consider that whilst the Prussian artisan may imbibe his beverage all day long from quart tankards with impunity, an English labourer will succumb to a few glasses of the public-house trash; what other inference can be drawn, than that it is not the beer but the drugs it contains which affect the brain? I have been told that English labourers will not take kindly to German beer; it is not strong enough for them. This is quite true of the present generation; how should it be otherwise, when their taste has been corrupted by *cocculus indicus*, tobacco, and salt? But unless the advocates of temperance strenuously support the introduction of a mild, pure, cheap drink (for the Englishman not alone buys bad beer, but pays three or four, aye in some cases five or six times as much for it as the German does for his unadulterated beverage), unless, I say, a vigorous effort is made to change the taste of the next generation as it grows up, the same difficulty will still remain to be overcome by posterity.

And now let me, in conclusion, refer to the data which have been given by an eminent Swiss social economist, to show (as I have done elsewhere†) that comparative sobriety is the result of

* For this test, I am indebted, through the kindness of Dr. Frankland, to Mr. W. Valentin, of the Royal College of Chemistry.

† 'The German Working Man,' p. 70, quoting Gustave Moynier, 'Les Institutions ouvrières de la Suisse. Cherbuliez: Paris.

the introduction of beer, and the displacement of stronger drinks. The canton of Soleure in Switzerland was formerly very intemperate, now it is much improved. This is partly attributable to the opening of small shops where *good* coffee (a thing unknown to the poorer classes in England) along with small white rolls and butter are sold; but concurrently with that, a change has taken place in the alcoholic drinks of the people, which is represented by the following figures, denoting a Swiss measure of 1½ litre:—

Consumed in	Swiss Wines.	Foreign Wines.	Beer and Cider.	Brandy.
1863	1,334,865	637,166	23,168	126,443
1865	1,483,546	953,944	84,972	121,120

The total consumption of alcoholic liquor, therefore, had increased altogether nearly 30 per cent., but the beer consumed was augmented threefold, whilst brandy had fallen off 4 per cent.!

Couple this experience with the fact that the Germans drink certainly as much, if not more beer than we do, and are sober, whilst we are perhaps the most drunken nation on the earth, and I conceive no one will dispute the proposition so often advanced by me, that as claret and light Continental wines are slowly reforming our middle classes, so will it be necessary to introduce mild, pure beer as a staple drink, in order to attain the same end amongst the labouring population. Until that is done, I am convinced that not all the efforts of temperance advocates (whose self-denial every one must admire and respect), neither lectures, tea-meetings, denunciation, nor repressive legislation, will avail anything beyond saving here and there a drowning wretch from the flood of poisoned liquor with which our large towns are deluged, but such a change as I have suggested being accomplished, I believe that, with the spread of education, and the introduction of more rational amusements than those now offered to the humbler classes, repressive legislation will be no longer needed; the ranks of our criminals, paupers, and lunatics will be thinned, and it is to be hoped the foulest blot will in time be removed from our national escutcheon.

II. SPIRITUALISM VIEWED BY THE LIGHT OF MODERN SCIENCE.

By WILLIAM CROOKES, F.R.S., &c.

SOME weeks ago the fact that I was engaged in investigating Spiritualism, so called, was announced in a contemporary;* and in consequence of the many communications I have since received, I think it desirable to say a little concerning the investigation which I have commenced. Views or opinions I cannot be said to possess

* The 'Athenæum.'

on a subject which I do not pretend to understand. I consider it the duty of scientific men who have learnt exact modes of working, to examine phenomena which attract the attention of the public, in order to confirm their genuineness, or to explain if possible the delusions of the honest and to expose the tricks of deceivers. But I think it a pity that any public announcement of a man's investigation should be made until he has shown himself willing to speak out.

A man may be a true scientific man, and yet agree with Prof. De Morgan when he says,—"I have both seen and heard, in a manner which would make unbelief impossible, things called spiritual, which cannot be taken by a rational being to be capable of explanation by imposture, coincidence, or mistake. So far I feel the ground firm under me; but when it comes to what is the cause of these phenomena, I find I cannot adopt any explanation which has yet been suggested. . . . The physical explanations which I have seen are easy, but miserably insufficient. The spiritual hypothesis is sufficient, but ponderously difficult."

Regarding the sufficiency of the explanation I am not able to speak. That certain physical phenomena, such as the movement of material substances, and the production of sounds resembling electric discharges, occur under circumstances in which they cannot be explained by any physical law at present known, is a fact of which I am as certain as I am of the most elementary fact in chemistry. My whole scientific education has been one long lesson in exactness of observation, and I wish it to be distinctly understood that this firm conviction is the result of most careful investigation. But I cannot, at present, hazard even the most vague hypothesis as to the cause of the phenomena. Hitherto I have seen nothing to convince me of the truth of the "spiritual" theory. In such an inquiry the intellect demands that the spiritual proof must be absolutely incapable of being explained away; it must be so strikingly and convincingly true that we cannot, dare not deny it.

Faraday says, "Before we proceed to consider any question involving physical principles, we should set out with clear ideas of the naturally possible and impossible." But this appears like reasoning in a circle: we are to investigate nothing till we know it to be *possible,* whilst we cannot say what is *impossible,* outside pure mathematics, till we know everything.

In the present case I prefer to enter upon the inquiry with no preconceived notions whatever as to what can or cannot be, but with all my senses alert and ready to convey information to the brain; believing, as I do, that we have by no means exhausted all human knowledge, or fathomed the depths of all the physical forces, and remembering that the great philosopher already quoted said, in reference to some speculations on the gravitating force,

"Nothing is too wonderful to be true, if it be consistent with the laws of nature; and in such things as these, experiment is the best test of such consistency."

The modes of reasoning of scientific men appear to be generally misunderstood by spiritualists with whom I have conversed, and the reluctance of the trained scientific mind to investigate this subject is frequently ascribed to unworthy motives. I think, therefore, it will be of service if I here illustrate the modes of thought current amongst those who investigate science, and say what kind of experimental proof science has a right to demand before admitting a new department of knowledge into her ranks. We must not mix up the exact and the inexact. The supremacy of accuracy must be absolute.

The first requisite is to be sure of facts; then to ascertain conditions; next, laws. Accuracy and knowledge of detail stand foremost amongst the great aims of modern scientific men. No observations are of much use to the student of science unless they are truthful, and made under test conditions; and here I find the great mass of spiritualistic evidence to fail. In a subject which, perhaps, more than any other, lends itself to trickery and deception, the precautions against fraud appear to have been, in most cases, totally insufficient, owing, it would seem, to an erroneous idea that to ask for such safeguards was to imply a suspicion of the honesty of some one present. We may use our own unaided senses, but when we ask for instrumental means to increase their sharpness, certainty, and trustworthiness under circumstances of excitement and difficulty, and when one's natural senses are liable to be thrown off their balance, offence is taken.

In the countless number of recorded observations I have read, there appear to be few instances of meetings held for the express purpose of getting the phenomena under test conditions, in the presence of persons properly qualified by scientific training to weigh and adjust the value of the evidence which might present itself. The only good series of test experiments I have met with were tried by the Count de Gasparin, and he, whilst admitting the genuineness of the phenomena, came to the conclusion that they were not due to supernatural agency.

The pseudo-scientific spiritualist professes to know everything: no calculations trouble his serenity, no hard experiments, no long laborious readings; no weary attempts to make clear in words that which has rejoiced the heart and elevated the mind. He talks glibly of all sciences and arts, overwhelming the inquirer with terms like "electro-biologize," "psychologize," "animal magnetism," &c. —a mere play upon words, showing ignorance rather than understanding. Popular science such as this is little able to guide discovery rushing onwards to an unknown future; and the real workers

of science must be extremely careful not to allow the reins to get into unfit and incompetent hands.

In investigations which so completely baffle the ordinary observer, the thorough scientific man has a great advantage. He has followed science from the beginning through a long line of learning, and he knows, therefore, in what direction it is leading; he knows that there are dangers on one side, uncertainties on another, and almost absolute certainty on a third: he sees to a certain extent in advance. But, where every step is towards the marvellous and unexpected, precautions and tests should be multiplied rather than diminished. Investigators must work; although their work may be very small in quantity if only compensation be made by its intrinsic excellence. But, even in this realm of marvels,—this wonder-land towards which scientific inquiry is sending out its pioneers,—can anything be more astonishing than the delicacy of the instrumental aids which the workers bring with them to supplement the observations of their natural senses?

The spiritualist tells of bodies weighing 50 or 100 lbs. being lifted up into the air without the intervention of any known force; but the scientific chemist is accustomed to use a balance which will render sensible a weight so small that it would take ten thousand of them to weigh one grain; he is, therefore, justified in asking that a power professing to be guided by intelligence, which will toss a heavy body up to the ceiling, shall also cause his delicately-poised balance to move under test conditions.

The spiritualist tells of tapping sounds which are produced in different parts of a room when two or more persons sit quietly round a table. The scientific experimenter is entitled to ask that these taps shall be produced on the stretched membrane of his phonautograph.

The spiritualist tells of rooms and houses being shaken, even to injury, by superhuman power. The man of science merely asks for a pendulum to be set vibrating when it is in a glass case and supported on solid masonry.

The spiritualist tells of heavy articles of furniture moving from one room to another without human agency. But the man of science has made instruments which will divide an inch into a million parts; and he is justified in doubting the accuracy of the former observations, if the same force is powerless to move the index of his instrument one poor degree.

The spiritualist tells of flowers with the fresh dew on them, of fruit, and living objects being carried through closed windows, and even solid brick-walls. The scientific investigator naturally asks that an additional weight (if it be only the 1000th part of a grain) be deposited on one pan of his balance when the case is locked. And the chemist asks for the 1000th of a grain of arsenic to be carried through the sides of a glass tube in which pure water is hermetically sealed.

The spiritualist tells of manifestations of power, which would be equivalent to many thousands of "foot-pounds," taking place without known agency. The man of science, believing firmly in the conservation of force and that it is never produced without a corresponding exhaustion of something to replace it, asks for some such exhibitions of power to be manifested in his laboratory, where he can weigh, measure, and submit it to proper tests.*

For these reasons and with these feelings I began an inquiry suggested to me by eminent men exercising great influence on the thought of the country. At first, like other men who thought little of the matter and saw little, I believed that the whole affair was a superstition, or at least an unexplained trick. Even at this moment I meet with cases which I cannot *prove* to be anything else; and in some cases I am sure that it is a delusion of the senses.

I by no means promise to enter fully into this subject; it seems very difficult to obtain opportunities, and numerous failures certainly may dishearten anyone. The persons in whose presence these phenomena take place are few in number, and opportunities for experimenting with previously arranged apparatus are rarer still. I should feel it to be a great satisfaction if I could bring out light in any direction, and I may safely say that I care not in what direction. With this end in view, I appeal to any of my readers who may possess a key to these strange phenomena, to further the progress of the truth by assisting me in my investigations. That the subject has to do with strange physiological conditions is clear, and these in a sense may be called "spiritual" when they produce certain results in our minds. At present the phenomena I have observed baffle explanation; so do the phenomena of thought, which are also spiritual, and which no philosopher has yet understood. No man however denies them.

The explanations given to me, both orally and in most of the books I have read, are shrouded in such an affected ponderosity of style, such an attempt at disguising poverty of ideas in grandiloquent language, that I feel it impossible, after driving off the frothy diluent, to discern a crystalline residue of meaning. I confess that the reasoning of some spiritualists would almost seem to justify Faraday's severe statement—that many dogs have the power of coming to much more logical conclusions. Their speculations utterly ignore all theories of force being only a form of molecular motion, and they speak of Force, Matter, and Spirit, as three distinct

* In justice to my subject, I must state that, on repeating these views to some of the leading "spiritualists" and most trustworthy "mediums" in England, they express perfect confidence in the success of the inquiry, if honestly carried out in the spirit here exemplified; and they have offered to assist me to the utmost of their ability, by placing their peculiar powers at my disposal. As far as I have proceeded, I may as well add that the preliminary tests have been satisfactory.

entities, each capable of existing without the others; although they sometimes admit that they are mutually convertible.

These spiritualists are certainly not much in advance of an alchemical writer, who says—

> "I asked Philosophy how I should
> Have of her the thing I would.
> She answered me when I was able
> To make the water malliable,
> Or else the way if I could finde,
> To mesure out a yard of winde;
> Then shalt thou have thine own desire,
> When thou canst weigh an ounce of Fire;
> Unless that thou canst do these three,
> Content thyselfe, thou get'st not me."

It has been my wish to show that science is gradually making its followers the representatives of care and accuracy. It is a fine quality that of uttering undeniable truth. Let, then, that position not be lowered, but let words suit facts with an accuracy equal to that with which the facts themselves can be ascertained; and in a subject encrusted with credulity and superstition, let it be shown that there *is* a class of facts to be found upon which reliance can be placed, so far, that we may be certain they will never change. In common affairs a mistake may have but a short life, but in the study of nature an imperfect observation may cause infinite trouble to thousands. The increased employment of scientific methods will promote exact observation and greater love of truth among inquirers, and will produce a race of observers who will drive the worthless residuum of spiritualism hence into the unknown limbo of magic and necromancy.

If spiritualists would but attend to the teachings of their own prophets, they would no longer have to complain of the hostile attitude of Science; for hear what Thomas L. Harris urges, in his 'Lyric of a Golden Age!'

> "The nearer to the practical men keep—
> The less they deal in vague and abstract things,
> The less they deal in huge mysterious words—
> The mightier is their power.
>
> * * * *
>
> The simplest peasant who observes a truth,
> And from a fact deduces principle,
> Adds solid treasure to the public wealth.
> The theorist, who dreams a rainbow dream,
> And calls hypothesis philosophy,
> At best is but a paper financier,
> Who palms his specious promises for gold.
> Facts are the basis of philosophy;
> Philosophy the harmony of facts
> Seen in their right relation."

III. THE RATE OF GEOLOGICAL CHANGE.

By H. M. Jenkins, F.G.S., Secretary of the Royal Agricultural Society of England.

Public opinion on questions of theoretical geology grows slowly, and usually precedes the statement of important speculations. The progress of discovery leads up to the induction, which, after floating more or less hazily in the minds of geologists for a certain time, is at last enunciated piecemeal at irregular intervals by the more daring theorists. Finally the scattered fragments are collected and arranged, bound together by the idea which connects them, and placed on record as a complete whole. This last is the task which I propose to attempt in reference to the progress of public opinion on the subject at the head of this article.

But first, let me clear the way by a short summary of the ideas which prevail amongst English geologists, so far as they bear on this subject. The prominent feature of the favourite modern school of geology in England—Uniformitarianism—is the belief that the forces in operation at the surface of the earth in former times differed in no appreciable degree from those now in action. This article of faith is, however, commonly restricted to what, for convenience of expression, has been termed "Geological time"—a period which is entirely represented by the rocks found on the earth's surface, from the oldest to those now in course of formation. According to this school, *the rate of geological change* has been approximately equal throughout the vast period which has elapsed since the deposition of the oldest stratified rock. Local variations of this law would doubtless be admitted by even the most thorough advocate of Uniformity, but the broad general principle characteristic of the creed is equality in the rate of change throughout all geological time.

Catastrophism, which is the name usually given to the other great school of geologists, is distinguished broadly by the tenet that in past times the forces in operation at the surface of the globe were of far greater intensity than they are now, and that great physical changes were then produced by more or less violent cataclysms. Probably there are geologists who now-a-days reject the catastrophes, but still cling to the belief that modern forces are much less intense, and modern changes much less rapid and extensive, than those which occurred in former geological periods. Therefore, whichever view we take of this theory, it is clear that its advocates believe that *the rate of geological change* was greater in past times than it is now; and the inference appears fair that, according to this school, the rate of change has, on the whole, progressively diminished from the earliest down to modern times.

In his Anniversary Address to the Geological Society last year, Professor Huxley defined a "third phase of geological speculation, namely, Evolutionism." This doctrine, in the words of the author, "embraces all that is sound in both Catastrophism and Uniformitarianism, while it rejects the arbitrary assumptions of the one, and the, as arbitrary, limitations of the other." To my mind it cannot well be distinguished from ordinary Theoretical Geology, unfettered by the trammels of any school; but obviously, the Evolutionist is prepared to accept whatever theory on *the rate of geological change* can be shown to be consistent with those known facts which can fairly be quoted as evidence.

The title of this article is capable of more than one interpretation, and in its various meanings it has already been investigated by speculative geologists. The late Professor Edward Forbes, in his lecture before the Royal Institution, "On the Manifestation of Polarity in the Distribution of Organized Beings in Time,"* endeavoured to show that the rate of development of *generic* types reached its maximum intensity, firstly, during the earlier Palæozoic periods, and secondly, during the later Neozoic periods; that is to say, near the beginning and the end of the geological scale. Again, the rate of development was shown to be at its minimum during the later Palæozoic (Permian) and earlier Neozoic (Triassic) periods, from which contiguous zero-points the development of generic types was asserted to increase in both directions.† This relation Professor Forbes termed "Polarity," and he showed how in several of the great divisions of the animal kingdom, two of their groups appeared to exercise a kind of "reciprocity," as, for instance, our old friends the Palæozoic four-starred corals *versus* the Neozoic six-starred. But Professor Forbes was careful to make the reservation that "the numbers of species in a group or genus at any given epoch is to be excluded, not being an element in the discussion of the question, though apt to be introduced through mistake of the nature of the generalization attempted to be attained." Indeed, the relations of individuals, species, and genera were favourite subjects of speculation with this poetic and philosophical palæontologist; and the generalization we have just sketched was a sequel to some other inquiries, in recording which he defines a genus as "an abstraction—an idea—but an idea impressed on nature, and not arbitrarily dependent on man's conceptions."‡ Again, "a genus consists of more or fewer of these *manies resulting from one* [species] linked together, not *by a relationship of descent*, but *by*

* 'Notices of the Meetings of the Royal Institution,' vol. i., p. 428.

† This view may be correct; but at present, as at the time when it was advanced, we have only negative evidence in support of it; and it is still very possible that Permian and Triassic rocks, rich in generic types, may be discovered in some hitherto unexplored region of the earth.

‡ 'Notices,' &c., vol. i., p. 196.

an affinity dependent on a divine idea."* It is necessary to bear in mind these definitions of a genus in order to understand the author's generalization of "Polarity" in the "development of generic types," and to prevent confusion with other ideas which I shall attempt to elucidate in the following pages.

Before estimating the rate of geological change in successive epochs, we must clearly understand the means by which that rate is measured. Our geological chronology is divided into epochs of greater or less extent, distinguished and characterized by certain forms of animal and vegetable life, either peculiar to them, or preponderating in number and variety during their continuance. We can conceive that in a previously unexplored country, far away from any region whose geology is known, the explorer may meet with diverse geological formations, each formation being characterized by a sufficiently numerous and distinctive fauna. If formation A contains 1000 species, and is 10,000 feet thick, and formation B contains 5000 species, but is only 1000 feet thick, and if the range of zoological rank in the 5000 species is approximately the same as in the 1000 species, we should be justified in saying of formation A, that, in comparison with formation B,—

(1) It was deposited very quickly; or,

(2) During its deposition species changed very slowly.

Further investigation by our hypothetical explorer might possibly furnish him with evidence that, during the deposition of formation A, the conditions of climate and physical geography had remained more or less stationary, and that the strata were deposited slowly. On the other hand, formation B and its fossils might yield evidence of great changes in climate and physical geography, and of comparatively rapid deposition. Under these circumstances, he would be justified in the conclusion that, during the epoch represented by formation A, the *rate of geological change* was much less rapid than during the period represented by formation B.

This hypothetical contrast will assist the reader in appreciating the significance of the following synopsis of the Palæozoic and Mesozoic rocks and their fossils, and will enable him to estimate how far these epochs agree with those which we have supposed to be represented by formations A and B respectively.

Professor Phillips, in his Rede lecture, delivered before the University of Cambridge in 1860,† remarks that if we select among the marine classes of animals those which are represented in all the great periods of geology, count the number of species yet discovered in them in British strata, and refer them at present to only three great periods, we find that the Palæozoic rocks contain 2729 species,

* *Loc. cit.*

† Afterwards published under the title of 'Life on the Earth.' Macmillan. 1860. See pp. 59–62.

the Mesozoic 2170, and the Cainozoic 1222. "The absolute number of marine species appears thus to be greatest in the Palæozoic strata; but when the thickness of the deposits, which represents elapsed time, is taken into account, the variety of forms in a given thickness or given period of time is very much less." This conclusion he illustrates by the following Table:—

	Total Species in eight Classes.	Maximum Thickness.	Relative Number of Species to 1000 feet.
Cainozoic strata	1,222	2,240	545
Mesozoic strata	2,170	23,190	164*
Palæozoic strata	2,729	57,154	41†

And he again observes (p. 62), "Thus it appears certain that the *variety of life* estimated by the marine tribes existing in a given period is greater in the more recent periods."‡

* Should be 93. † Should be 47.

‡ The editor of this Journal (Mr. James Samuelson) has asked me whether I may not have overlooked the biological aspect of the case, and whether this may not be the result of the laws of selection in the lower forms of life varying from those in the higher forms, and the rate of change being perhaps more rapid in the latter; *e.g.* low molluscs or acalephs having predominated in earlier times, might go on multiplying for ages without material change, their conjugation being, like that of plants, regulated by the elements, whilst in the fishes and higher molluscs, sexual selection and destruction of each other would be very active and would produce rapid change of species. It appears to me that at least two powerful arguments may be advanced against this interpretation. First, geologically considered, the interpretation would be erroneous because we are contrasting the abundance and variety of life characteristic of the different great periods, and it cannot be said of any one great period that it is characterized, for instance, exclusively by low molluscs, nor of any other that it is characterized exclusively by higher orders of that class, as is shown in the following Table by Professor Phillips:—

	Zoophyta.	Echinodermata.	Crustacea.	Brachiopoda.	Monomyaria.	Dimyaria.	Gasteropoda.	Cephalopoda.	Total.
Cainozoic ..	27	41	15	8	63	394	662	12	1222
Messozoic ..	103	245	65	165	308	499	389	396	2170
Palæozoic ..	379	225	218	632	196	342	401	336	2729

Thus the Palæozoic rocks abound both in the highest and the lowest orders of the testaceous Mollusca, *viz.* the Cephalopoda and the Brachiopoda, while the Tertiary deposits are characterized by the intermediate groups of Gasteropoda and Lamellibranchiata. The oldest fishes are not regarded by the best authorities as of uniformly lower types than the most recent; and with regard to the power of sexual selection, the advantage is doubtless on the side of the Palæozoic and Mesozoic representatives of the modern Claspers. But the weightiest argument, to my mind, is to be derived from the improbability that sexual selection in such animals (for, owing to our imperfect record, we are necessarily compelled to deal almost exclusively with animals of no high zoological grade) was to any great extent the result of direct volition, or that sexual selection was the determining cause of change of species, although it no doubt was one means to that end. It appears to me far more probable that changes in species have been rapid

These quotations show that so keen an observer and so thoughtful a philosopher as Professor Phillips had not allowed this subject to escape him; but I am not aware that any other geologist has discussed it from precisely the same point of view. The figures given by Professor Phillips show that the rate of geological change, with regard to the *relation between the deposition of strata and the changes in faunæ*, was neither uniform throughout all geological times, as the Uniformitarians would have it, nor more intense in the earlier periods, as the Catastrophists contend. On the contrary, these figures prove, to the extent which they go, that the rate of change was marvellously more rapid in the more recent periods, and that the increase in rapidity was rapidly progressive, from the earliest to the latest times. There are four times as many species* belonging to the eight classes which are persistent through all geological periods, per 1000 feet, in the Mesozoic strata than in the Palæozoic, and there are three times the number † of such species per 1000 feet in the Cainozoic strata that there are in the Mesozoic.

In the same year (1860), Professor Phillips, as President of the Geological Society, delivered the Anniversary Address to the Fellows, and again adverted to this subject, and the following quotation gives his conclusions, as delivered before one of the most critical geological audiences in Europe:—

"In the earlier periods of the world's history, the changes of life in the sea were accomplished at a rate *much less rapid than that which prevailed in later times*,‡ which agrees with the acknowledged very wide distribution of Palæozoic forms in geographical space. Admitting the changes of life on the whole to be equal from the Palæozoic to the Mesozoic, and from these to the Cainozoic periods, we find the rate of progressive change § $\frac{1}{70}$th for Palæozoic, $\frac{1}{18}$th for Mesozoic, and $\frac{1}{3}$rd for Cainozoic time,—a conclusion of great importance, and probably indicative of the greater influence and

or slow, in proportion as changes in climate and physical geography have been frequent or seldom. In the Palæozoic periods we have reason to believe that changes in physical geography were rare, while the climate and the nature of the earth's surface were very slightly diversified. In the Tertiary epoch, on the contrary, climate and physical conditions have been very diverse, and have frequently varied; and these variations have been accompanied by proportionate changes of species. If periods of small duration had been compared by Professor Phillips, it is quite certain that the chances of error would have been very great; but by putting in contrast only the three great epochs into which Geological Time has been divided, I believe that those chances of error have been reduced to a minimum, according to the well-known law of averages.—H. M. J. With all deference to so eminent a geologist as Professor Phillips, and to the author of this essay, it appears to me that such a table is an unsafe guide in the present state of the palæontological record. Here, for example, the fishes—the most important group of all, biologically—are entirely omitted.—EDITOR.

* According to my calculation, twice as many. † I make it six times.

‡ The italics are mine.—H. M. J.

§ Taking the unit of thickness such that it shall be $\frac{1}{100}$th of the ascertained strata in which life-traces occur.

superiority in early times of a slowly changing physical condition of the whole globe over the partial and irregularly varying local conditions, which were continually augmenting, and are still augmenting in influence with the lapse of time."

It may be objected to Professor Phillips's figures that he includes only the species belonging to the eight classes of animals which have been represented in each of the three great periods. I therefore give in the following Table the approximate total number of species (excluding plants only) that have been discovered in British stratified rocks up to the present time, with the result per 1000 feet, and the average number of feet per species in each great period:—

Periods.	Number of Species.	Maximum Thickness.	Relative Number of Species per 1000 feet.	Number of feet per Species.
Cainozoic	1,500	2,240	670	1·5
Mesozoic..	4,000	23,190	173	5·8
Palæozoic	3,500	57,124	61	16·3

The evidence yielded by the analysis of these figures is even more in favour of the conclusion that the *rate of geological change*, according to the evidence of animal life, has progressively *increased* from the earliest to the latest times.

With one other numerical illustration I shall close the argument drawn from the organic phase of the question. The late Professor Bronn, in his prize essay, and in the third edition of his 'Lethæa Geognostica,' gives the following as the total numbers of known species in 1850, just twenty years ago:—Palæozoic 6681, Mesozoic 10,879, and Cainozoic 15,138. If we assume the maximum thickness of the deposits of these periods to be 60,000, 25,000, and 10,000 * respectively, we get the following numbers of species as occurring per 1000 feet of strata:—Palæozoic 111, Mesozoic 435, and Cainozoic 1513; thus showing exactly the same result almost in the same proportions.

The foregoing calculations are based on the assumption that the time required for the deposition of 1000 feet of strata was approximately the same in the Palæozoic, Mesozoic, and Cainozoic periods, and so far the argument is Uniformitarian; but the received interpretation of the physical conditions which prevailed in those periods renders it probable that the strata were deposited more slowly in the earlier than in the later periods, which, *a fortiori*, adds considerable strength to my conclusion.

The inorganic aspect of the subject has been discussed more

* I purposely make this number very large, so as not to run the risk of being charged with making too much of my argument from this point of view.

frequently than that phase which we have just reviewed; but with this striking difference, that no geologist has treated it from the point of view of pure geology in the same direction as Professor Phillips has from a palæontological standpoint,—the geological arguments are all either purely Uniformitarian, or as purely Catastrophic.

In the second of two essays "On the Measurement of Geological Time," which were published in 'Nature' only a few weeks ago,* Mr. Wallace touches on this question. He remarks † that for the last 60,000 years the eccentricity of the earth's orbit has been very small, and that therefore the opposite phases of precession, each lasting 10,500 years, have during that time produced scarcely any effect on climate. This state of things, however, is regarded by him, as by Mr. Croll, as quite exceptional, for during nearly the whole of the last three million years the opposite state of things has existed, namely, a high eccentricity coupled with a change (in the extra-tropical regions) every 10,500 years, from a very cold to a very mild climate. Mr. Wallace therefore argues as follows:—"This will necessarily have caused much migration both of plants and animals, which would inevitably result in much extinction and comparatively rapid modification. Allied races would be continually brought into competition, altered physical conditions would induce variation, and thus we should have all the elements for natural selection and the struggle for life to work upon and develop new races. High eccentricity would therefore lead to a rapid change of species, low eccentricity to a persistence of the same forms; and, as we are now, and have been for 60,000 years, in a period of low eccentricity, *the rate of change of species during that time may be no measure of the rate that has generally obtained in past geological epochs.*"

I shall not stop to criticize Mr. Wallace's attempt to measure geological time, as Mr. Dawkins has already pointed out the fallacy involved in the major premiss of this argument, *viz.* that all climatal change has depended solely on the eccentricity of the earth's orbit.‡ It is sufficient for my present purpose to point out that Mr. Wallace recognizes the principle that *the rate of change of species* may have varied in different geological epochs. To refer the cause of its variation to differences in the eccentricity of the earth's orbit is probably erroneous, but that error of ultimate explanation by no means diminishes the importance or the stability of the fact which is thus sought to be explained.

Both Sir Charles Lyell and Mr. Wallace have attempted to estimate the duration of the several geological epochs, basing their calculations on a supposed rate of change in species of marine mollusca. In this way Sir Charles Lyell concludes that "we may

* February 17th and March 3rd. † *Loc. cit.*, March 3rd, pp. 453 and 454.
‡ See 'Nature,' March 17, p. 505.

consider a million years to represent the twentieth part of a complete revolution in species, and we might thus estimate the number of years required for the elaboration of the successive Tertiary formations." Proceeding thus, Sir Charles Lyell calculates that two hundred and forty millions of years have elapsed since the beginning of the Cambrian period. Mr. Wallace, however, by taking the same facts and figures, manipulates them differently, and comes to the conclusion that the lapse of time is exactly one-tenth of that estimated by Sir Charles Lyell. This difference of result is of very little consequence, as both calculations are equally speculative, and it is chiefly to a point of resemblance that I wish to draw attention.

Sir Charles Lyell and Mr. Wallace, however much they may differ in other matters, whether they regard the revolution of species as having been accomplished in no less a period than twenty millions, or in one no greater than two millions, are agreed in using the same *rate of change* for the Palæozoic as for the more recent periods. Taking the figures of the latter author, and calculating the time required for the deposition of strata on his hypothetical rate of change in species, we get at the following results:—

Periods.	Duration (Wallace).	Thickness of Rocks (England).	Rate of Deposit; years per foot.
Cainozoic	6,000,000	2,240	2,678
Mesozoic	8,000,000	23,190	345
Palæozoic	10,000,000	57,124	175

It may be urged that the Tertiary rocks are comparatively thin in England, owing to the absence of Miocene deposits; but the same argument may be applied to each of the three periods with greater or less force; and at any rate the relative rapidity of deposit would not be very much disturbed if we took the maximum thickness all over the world instead of those occurring in the British Islands. Leaving denudation entirely out of the question, it does not seem at all probable that the Palæozoic rocks should have been deposited at the swift rate of one foot in 175 years; and if we deduct from the calculation the period represented by "breaks," which Professor Ramsay regards as longer even than that represented by strata, we shall have the conclusion drawn that the Palæozoic rocks were deposited at the rate of one foot in less than a century! At the present day there are many localities peculiarly favourable to the rapid accumulation of deposits over limited areas, as, for instance, the deltas of the great rivers; but even in such cases the rate of deposition is probably not more than what, according to Mr. Wallace's estimate, must have been general all over the aquiferous surface of the earth during Palæozoic times.

Whether we measure the relative lapse of time occupied by the successive events of Geological History by the known facts of the accumulation of deposits, or by the comparative changes which have occurred in the life of successive periods, we are led equally to infer that the *rate of geological change* has been more rapid in the later than in the earlier geological periods, and that that rate has increased progressively from the earliest to the latest times.

Such an inference, though it may at first sight seem heretical, is in reality but the natural result of those conditions of the earth's surface which the most orthodox geologists regard as characteristic of successive periods. A greater uniformity of climate and of surface in the earlier Palæozoic periods than at the present day has long been considered the legitimate inference to be drawn from the thick masses of uniform deposits spread over large areas, and containing species of fossils possessing an enormous geographical distribution. In ascending the geological scale the deposits gradually become more differentiated, and the fossils belong to species which had a more restricted geographical range; these differences are usually and properly regarded as the result of greater diversity of climate and surface-configuration during the later periods, and these more diversified conditions must have been accompanied by a greater rapidity in the rate of geological change, if for no other reason than that there were a greater number of *centres of change*, acting and reacting on each other.

IV. AIR-POLLUTION BY CHEMICAL WORKS.

A MANUFACTURER, having realized his primary object of making what he can out of the materials which pass under his hands, and having utilized all that he deems valuable in them, finds there is yet another need to be fulfilled; he must get rid of his refuse, and that as speedily as possible. Our present object is to watch this latter operation, and, losing sight of the beautiful or useful results of his work, to direct our attention to what is waste or refuse, and inquire how he disposes of it. When this is solid and bulky, it must be removed at the cost of much labour, and a place must be provided where it can be deposited. When the refuse is a liquid, the process of getting rid of it is generally less expensive; it will flow away in the water-courses if only proper drains and passages are provided. When the refuse is gaseous, this process of removal is easier still; no passages need be cut, no culverts nor bridges built, the vapour can be allowed to pass into the air, and is blown away.

In each of these cases the manufacturer's object is attained; he is rid of the refuse, and has room for renewed work. Unfortunately,

however, although he is rid of it, his neighbours are not so; they find, on the one hand, that the water of their brook is no longer fit for use, nor pleasant to look at, and the air they breathe is polluted with unsavoury and noxious vapours. Where a manufactory of this kind stands alone, or where only those who are dependent on it for their subsistence dwell in its vicinity, this state of things goes on for a long time without calling forth much complaint. Sooner or later, however, complaints must come; we cannot all live at arm's length. Population increases, we are pressed together, and valuable though the various products of manufacturing industry may be, pure air and pure water are more valuable still. Yet we cannot do without the manufactory, unless we return to barbarism. A naked savage eating uncooked roots erects no chimney to pour its black or acrid vapour into the air; he discharges the liquor from no dye back into the clear brook of the glen—but he remains a savage. We must keep our manufactories; by their products we are warmly clothed, our houses are firmly built and are decorated with colours; the wind is shut out by panes of transparent glass; the paper on which we write is white and fair. These and a thousand other things are the results of many a mechanical or intricate chemical process, the waste products from which, solid, liquid, and gaseous, are unpleasant enough.

If, then, we will not go back to barbarism to get rid of our smoke and our dirty water, can we go forward and by greater skill diminish or suppress them? The answer *must be* "Yes." Yet those only who have to work out the problem know with what difficulty this answer has in many cases been given, whilst in many it is not given yet.

The materials which the manufacturer throws away, we have already classed in correct school-room fashion as solid, liquid, and gaseous. With the first of these the manufacturer alone is concerned, and it may be safely left in his charge. The more of it he produces, the more must he expend in its removal, the more land must he purchase on which to deposit it; and if he throws away that which is valuable, he is the chief loser. We may, therefore, safely leave him, with certain reservations, to look after his solid refuse, knowing that no sharper impulse can be applied to induce him to diminish its amount, or to save what is valuable in it, than the spur of self-interest which already exists. We say it may be safely left in his charge; but if, through some process of fermentation or change, a portion of it shall slip out of his custody, and yield, after rain, a noxious liquid to drain into the nearest brook, or a gaseous escape to contaminate the air around, it falls back into the two other classes.

For the present we propose to direct attention to the latter of these two classes only, the gaseous. In doing so, we would first dwell

on the magnitude of the evil which may and does arise from the pollution of the atmosphere by gases discharged during the carrying on of various manufacturing processes; secondly, on the state of our laws on the subject; and thirdly, as to the direction which further legislation on the subject should take.

The evils complained of are not uniformly spread throughout the country, and do not come under the observation of everyone. Some districts are found to be specially suitable for carrying on a particular manufacture, so throughout the country we find works of a certain kind grouped together. Those who reside in the districts known as "manufacturing," are too familiar with the evils arising from noxious vapours floating in the air to need any setting forth of their extent, unless indeed familiarity with these evils has dimmed the perception of their magnitude. In Staffordshire, the so-called "black" country is a district of many miles in extent, blasted by the smoke of the iron furnaces; in it not a tree can be found, and scarce a blade of grass. Near St. Helens and Widnes in Lancashire scarce a living tree is seen in the direction towards which the prevailing winds blow, and in the valley of Swansea, thickly set with copper works, not only are the hill-sides bared of the green forests which once waved there, but the underwood, the shrubs, the hedge-rows, the grass itself is gone, and, to complete the desolation, when the roots and fibres which permeated the soil died and rotted, the soil itself, no longer able to withstand the action of the rain, was also washed away, leaving only bare heaps of stone and gravel. These, more like huge railway embankments than natural hill-sides, suffer yet another injury, for the rain, not now absorbed and held back by tree, shrub, grass, roots, or soil, falls on the bare hill-side, as on the slated roof of a house, and as quickly runs off it, ploughing the ground in its headlong course, making each rippling streamlet into a torrent even during a moderate shower. And still the desolation is not fully described, for when the even adjustment of nature is disturbed, who shall say where the derangement will stop? Here the grass, the soil is gone, and with these the insects and birds, with the exception of a few sparrows.

The manufacturing processes which may give rise to noxious vapours are numerous. The French, in the elaboration of their sanitary code, enumerate seventy-four.

These noxious vapours may do injury of two kinds—injury to animal life and to vegetation.

Injury of the former class, though real and widespread, is a matter less easily brought to the measure of money than that of the second class. People are annoyed at a vile smell arising from some manufacturing process, and by its continuance are affected in health, but they do not assess the damage in money and sue for it at law, except in so far as property is injured. Where, however, in

an already populous district a factory is established, the emanations from which can be proved to be injurious to human health, there is power for suppressing the nuisance; for, under the Sanitary Act (18 & 19 Vict., c. 121), the "Local authority, when moved by its Medical Officer of Health, or by two legally qualified practitioners, or by ten householders residing in the district in which the nuisance exists, is bound to complain to the magistrates (two lay, or one stipendiary) and to prosecute the offenders. The penalty, if the case is proved, is a fine of from 40*s.* to 5*l.* for the first conviction, 10*l.* for the second, and for each subsequent conviction a sum double the amount of the penalty imposed on the last preceding conviction, but so that such cumulative penalty do not in any case exceed 200*l.*"

The operation of the law here is clear, and generally satisfactory. This clearness, however, ceases when we turn to the working of the law in cases of injury done to vegetation. The question is not now whether any damage is done to the farmer's crops and trees, but *how much;* for if an important manufactory is carried on, giving employment to a large number of workmen, producing articles of general value, and returning a handsome income to the proprietor, it would not be wise to put a stop to all this producing power, because it of necessity entails a small amount of collateral damage. Rather let those who carry on this lucrative manufacturing business compensate those who are injured by it; and consider that they have only fairly earned that amount which remains, when from their gross profits they have deducted this charge. In this way we have a gauge by which to determine the amount of forbearance which the public shall exercise towards a manufactory doing obvious damage to the vegetation around it.

If a factory produces a revenue of 1000*l.* to its proprietors, and at the same time injures neighbouring vegetation to the extent of 100*l.*, it clearly does more good than harm. The farmer is compensated, and 900*l.* is honestly earned after every one is satisfied. Put, however, the figures the other way; suppose the works, while earning 100*l.*, to do 1000*l.* worth of damage, and the proprietors compelled to pay this, it will require no injunction from the Court of Chancery to make them close the works, or else to improve the manufacturing process so as materially to lessen the damage done.

But we have hitherto considered only the relations of the manufacturer and the farmer, imagining the smoking chimney to be surrounded by corn or clover, orchards and hedge-rows. All these have a known market value, and can be paid for with money. In place of the farmer, with his marketable crops, imagine him or his landlord dwelling in the old house of his fathers. The trees which surround his cottage or his mansion are of ancient growth; the place is his home. What money shall compensate for its loss? He may be rich and put little value on pecuniary compensation. He

will feel himself grievously wronged when, his trees being killed, he is offered money in place of them.

This might be said, however, in all cases where the sanctity of private property is invaded. When a railroad is planned, which is to carry a nation's traffic, it will disturb many an ancient hall and many a cottage home. The money equivalent is paid the owner, but in his eyes this is often no sufficient compensation. He must, however, bow to his fate and give way before the greater good of the many. So in the case where a man sees every year the noble trees vanish from his land, from the ancient domain that has been held in quiet enjoyment by his family through many generations, and feels himself driven from it by the advancing tide of manufacturers. He is much to be pitied; for, let him be paid ever so liberally for the damage actually done to the estate, he is not compensated. Yet he must submit and suffer personal loss for the public benefit.

Fortunately, however, these cases are exceptional; generally those interested in the land can be fully compensated in money for all they lose. A farmer, who should get 100*l.* for the produce of his wheat-field, is content if it brings him in only 50*l.* in the market, provided he can get the remaining 50*l.* by way of damages from the neighbouring chemical manufactory. A question here at once arises, Will he have much difficulty in obtaining from the manufactory the 50*l.*, the proved amount of his loss? If the manufactory is standing by itself, he probably will have no great difficulty. If the demand is resisted, his course at law is plain. He proves that on a certain day, or on many days, the smoke of the offending chimney was seen to fall upon his land, that soon afterwards the crops were visibly injured, in such a way as is known to be caused by chemical smoke; he also further proves, by the assistance of agricultural valuers, that the amount of the damage done is an equivalent of the sum of money he now claims. This chain of evidence is usually so conclusive that the farmer wins the day.

Suppose, however, that in place of one chemical work being near the farm, there are several in a group, from all of which the smoke approaches simultaneously. These works may be of different kinds; there may be alkali-works and copper-smelting works; glass-works and potteries, with chemical works whose various processes and products defy enumeration, how shall the farmer discriminate, or rather how shall he criminate? how shall he fix on the culprit among such a motley crowd of evil doers? Let us suppose him calling on the first in order, and making his complaint against him, as the one he thinks most likely to have been the offender; the manufacturer explains to him in the clearest manner that from the nature of the processes he carries on, and the care with which all injurious vapours are avoided or condensed, he

cannot have injured the land; perhaps it was his friend of the neighbouring works, whose processes are different from his own. Doubtless this gentleman would be equally clear and conclusive in his explanations, and would pass our farmer on once more, to be sent in turn from one to the other, but to get redress from none.

The farmer soon learns that the only way in which he can obtain compensation from any of the chemical manufacturers is to fix on one of the works, perhaps the one nearest his land, or the one with the highest chimney, and to watch till he thinks he can distinguish the smoke from it come upon his farm. On that he fixes, and, shutting his eyes to the other works and forgetting the injury they probably do him, charges the proprietor with the whole of the damage he has sustained. The judges and juries before whom such cases come for trial are in great difficulty, they know that the manufacturer in question has not done all the damage alleged, yet they have no power of apportioning it between him and other offenders, therefore, as some of the damage has been proved to come from the defendant's works they give a verdict for the plaintiff.

Among chemical works, the largest, and those capable of doing most harm to vegetation, are the alkali-works. In these works soda, in its various forms of ash, carbonate, bicarbonate, crystal or caustic, is extracted from common salt. Common salt consists of soda in combination with muriatic acid. When it is mixed with sulphuric acid and heated, muriatic acid is driven off as a gas. In the earlier days of the soda manufacture this acid was considered as a waste product to be got rid of as speedily as possible. The easiest way was to let it pass into the chimney and thence into the surrounding atmosphere. Complaints were soon made that trees in the neighbourhood were injured. The manufacturer therefore raised his chimney, building it so high that the acid might be carried away to a great distance by the wind and its effects lost sight of. The result of this effort was not successful; on wet days the rain passing through the smoke would wash down the acid and fall in burning drops even at the foot of the chimney; while on fine days the smoke would travel farther and though much spread out, still powerful for evil, would carry on its destruction over a larger area. A wiser plan was next adopted; by the use of the now famous Gossage condensing towers the acid vapours were washed out of the smoke and kept from contaminating the air altogether. Those alkali manufacturers who carried out this method well sent out scarcely any acid vapour to damage the farmers' crops. Some of the manufacturers, however, were behindhand in the movement, and either from want of skill or of enterprise, did not condense their acid vapours. Of the efficiency of this condensation in individual cases the farmer could not judge; he found that his crops

were still damaged, and therefore brought his action as before, possibly to recover from an innocent party. At this point the Legislature stepped in, and in the Alkali Act of 1863, passed a measure which has worked well in the interests of both the manufacturers and the agriculturists. The Act announces it to be the duty of the manufacturer to condense 95 per cent. of the muriatic acid he produces, and fixes a penalty of 50*l*. for each omission, raising the penalty to 100*l*. after the first conviction. Inspectors are appointed, whose duty it is to visit the works from time to time and ascertain that the provisions of the Act are carried out. It should be noticed that the Legislature in passing this Act stepped out of its accustomed course. The common law maxim is that for every injury a man may receive he has his remedy against some one. He must, however, receive the injury before he can seek his remedy; but in this case, as it already has been shown, much injury may be done which has no remedy. Who can replace an oak tree of 100 years' growth and restore the waving woods which adorned the hill side? The law therefore here steps in beforehand, and no sooner does the Inspector find that 95 per cent. of the acid is not condensed, than he stops the process under the penalties mentioned. The new law has been found to work very well, it has enforced the condensation of muriatic acid to the benefit both of the manufacturer himself and of the public. It has protected the agriculturist against the manufacturer, and the manufacturer against the agriculturist. The Inspector is received as a friend by both sides; he protects the farmer's interests by enforcing care on the part of the manufacturer, and he protects the manufacturer's interest by proclaiming the extent to which he carries the suppression of noxious vapours. The Act has had the effect of bringing up the hindermost manufacturer to the rank of the most skilful. Before this legislation took place many manufacturers condensed a portion of their muriatic acid; now they all condense not a small portion only, but fully 95 per cent., some indeed habitually condense 99 per cent. The manufacturer finds the visits of the Inspector an assistance to him in keeping his condensing apparatus in efficient order; and an amount of acid escaping which would pass unnoticed by the master or his workpeople is detected by the Inspector. It should be understood that to point out leakage of muriatic acid is to point out waste, for this acid is needed in the manufacture of bleaching powder, and other products. The amount of acid thus saved by the operation of the Act is very large. One manufacturer sells muriatic acid annually to the amount of 1500*l*.—acid which previous to the passing of the Act was sent up the main chimneys of the works to the destruction of all surrounding vegetation.

It may now be asked in general terms, has the Alkali Act, this somewhat experimental law, succeeded; does it accomplish the work

it was intended to do? The reply is that it has done all and more than its promoters or those who understood its provisions expected; but probably the public generally are not satisfied; they fail to understand that a law which professes to shield them from muriatic acid cannot also defend them from chlorine, sulphurous acid, sulphide of hydrogen, and the host of nameless gases by which their noses and their gardens are assailed; still less can they understand that an Act which should prevent the emission of muriatic acid from the chimney of an alkali works, cannot also prevent the escape of the same acid from copper-extracting works, a bottle factory, or a pottery.

The Act must, however, not be blamed for omitting to do that which it was never framed to accomplish; let us be glad that a step has been gained, that one noxious gas has been measured and suppressed.

Some instances have occurred where manufacturers who are not alkali makers have desired to place their factories under the Inspector appointed under the Alkali Act. Their object being first to know if, in his opinion, they were sending out an injurious amount of noxious vapour, then, having diminished it so as to meet with his approval, to gain his advocacy and defence when harassed by their natural enemies the farmers. This has brought a certain amount of volunteer work on the Inspectors, which they have cheerfully borne on account of the obvious good they could accomplish, by diminishing on the one hand the escape of noxious acids, and preventing litigation on the other.

In districts such as that around St. Helens, in Lancashire, where alkali-works and copper-smelting works are found together, the copper smelters look somewhat enviously at the alkali makers.

Before the passing of the Alkali Act, the farmers who thought they had suffered loss through the injury of their crops by acid vapours, charged the damage sometimes against the alkali-works and sometimes against the copper-works. Now, however, owing to the improvements which have been made in the alkali-works under the stimulus of the Act, and supposing the manufacturers to be somewhat protected by it, the landholders direct their attacks exclusively against the copper smelters. The amounts claimed by each farmer are not always large, but the aggregate has reached 3000*l.* a year against the six copper-works.

Besides these smaller claims an important action was lately brought by the proprietor of an estate three miles from St. Helens against a copper smelter, for damage done to his trees and crops by the smoke from the works. The course the action took, so well shows the present working of the law, and indicates perhaps the direction in which it could be amended, that it might be well to give some account of it here.

The plaintiff proved he had received damage from smoke coming from the direction of the defendant's works, and alleged that the damage he had sustained was wholly done by them, intimating that if he gained a verdict in the present suit he should apply to the Court of Chancery for an injunction to restrain the carrying on of the works altogether, as he believed he would then be free from all damage. In defence it was pointed out that the defendant's works lay in a straight line between the plaintiff's land and St. Helens, so that the same wind which brought defendant's smoke would also convey the smoke from a large portion of St. Helens, and that in general, as the plaintiff's park was subject to injury from all the factories in the neighbourhood, it was unjust to charge the whole damage upon the defendant.

It will be seen that the following question would at once present itself:—Is it possible to determine the amount of damage which each factory in a district contributes towards the damage done by all?

In other words, if a farmer sustains a loss of 100*l.* through his crops being injured by the accumulated smoke of a manufacturing district, is it possible to set down to each manufacturer the amount which he ought to contribute towards this 100*l.*?

Turning to the fifth of Dr. R. Angus Smith's very able reports under the Alkali Act, we find this question anticipated and an answer given. Referring to the amount of acid vapours thrown up with the smoke of factory chimneys, he says at page 25:—"Now it is easy to estimate this amount, and it is easy to put down to every one in the district the exact share of guilt so far as the acid is concerned. . . . . Perhaps we may also bring in the element of distance."

In consequence of this Mr. Alfred E. Fletcher, the Inspector under the Alkali Act for the district which includes West Lancashire, was asked to apply himself to the question. He had to consider:

1st. The distance of each factory from the injured land.

2nd. The rate at which the increase of distance diminishes the power of the smoke to do damage.

3rd. The number of days throughout the year on which the wind blows from each point of the compass.

4th. The amount of acid vapour discharged from each factory in a given time.

First, the distances; these are easily measured on the map.

Information on the second point was obtained in the following manner. At a time when the ground was covered with snow for a week, lines were drawn, in a direction following the wind, from St. Helens and from other groups of works, to a distance of two or three miles. At each half-mile a sample of the surface snow was collected and brought home for analysis. Also during a period of rain, collecting vessels were set at regulated distances from a group

of works. A determination was then made of the amounts of muriatic and of sulphuric acids collected by the snow and by the rain, and these were compared with the distances at which the samples had been obtained. It was seen that the amounts diminished in even ratio with the increase of distance. Probably a sufficient number of experiments of this nature have not yet been made, firmly to establish the law; for the undulations of the ground, the position of trees, and any objects which interfere with the uniform motion of the air, affect the even deposition of the acid vapours. More experiments, it was said, were about to be undertaken in order to establish the law on a wider basis. Information on the third point may be usually obtained at some neighbouring observatory. In the case of St. Helens the returns of the direction of the wind, published at the Liverpool Observatory, on Bidston Hill, were depended on.

Fourthly, the amount of acid vapour discharged from each factory in a given time can be known by periodical examination of the gases which are passing up the various chimneys of the works. This is already done as far as the alkali-works are concerned under the provisions of the Alkali Act. In the cases of copper-smelting works, glass-works, and others where systematic inspection has not been carried on, the amounts of acid vapour thrown into the air can be calculated from the materials used in the manufacturing processes carried on.

The acid vapours discharged from the various works in the St. Helens district are:—From ten alkali-works,—muriatic acid, sulphuric acid, sulphurous acid, nitrous acid, chlorine, coal smoke; from nine glass-works,—muriatic acid, sulphuric acid, sulphurous acid, vapour of common salt, coal smoke; from six copper-smelting works,—sulphuric acid, sulphurous acid, coal smoke; from six collieries, six iron foundries, two soap-works, 8000 dwelling-houses, —coal smoke; from the Sankey Brook and the heaps of alkali waste,—sulphide of hydrogen.

This is a formidable list, but the amounts of each may be calculated with a very near approach to accuracy, except the last item, the sulphide of hydrogen, which varies continually with the amount of rain-fall, and with the temperature of the air.

Having, then, collected the information as set forth under these four heads, it became merely a question of figures to apply it to the solution of the problem raised in the St. Helens law-suit. A list was made out of the principal factories in the district capable of doing injury to the plaintiff's land. Opposite these was set down the distance of each factory from the land and, in a parallel column, the amount of acid vapour thrown up by each. On dividing the figures in the second column by those in the first, numbers were obtained which were proportioned to the share each one had contributed to the total damage done by all to the plaintiff's land.

Further, a method was adopted by Professor Roscoe, of Owen's College, Manchester, which confirmed the accuracy of this calculation.

St. Helens lies, as has been said, three miles from the plaintiff's park, defendant's works being half-way between them.

While the snow lay on the ground last February, the wind blew mainly from the east. Professor Roscoe then took samples of the snow lying three miles west of St. Helens, and also some of that lying a mile and a half west of defendant's works, that is, the same distance to the west as plaintiff's land is to the south-south-east. He found that the proportion of the amount of acid contained in the one to that contained in the other, agreed closely with the proportion determined by Mr. Fletcher in the previous calculation. This was given as evidence at the trial, and it appears that the jury acted on the principle here laid down, that a manufacturer should only be called on to pay in proportion to the amount he contributes to the total damage sustained, and that it is possible to ascertain what that amount should be. Since this trial two other similar cases have been decided by arbitration, in each of them the arbitrator showed by his award that he adopted the principles here set forth.

Having now given some account of the working of the Alkali Act, the most recent legislation on the difficult subject of air-pollution, and sketched the action of the law courts when matters of the kind are brought before them, it may be desirable to discuss the course which further legislation should take in the matter.

As regards the present Alkali Act, we would object that though successful it is too limited in its application.

Secondly, the onus of carrying out its penal clauses rests on the Inspector. We should have a noxious vapour Act applicable to every manufacture where injurious gases are thrown off. The duty of the Inspector should be solely to inspect and to publish the results of his inspection—the public should be the prosecutors.

Let us follow the working of such an Act. In every district its Inspector would, from time to time, publish a list of the works, together with the amounts of acid or other vapour escaping from them. This would be given either as the amount in 1000 cubic feet of the chimney gases, or the actual amount by weight of that which escapes per month or per annum. The result of this to the manufacturers would be that they would anxiously consult the published list and exercise a wholesome rivalry as to who should stand well in it. Moreover, these lists would form the basis for assessment of damages in case of claims made by the neighbouring farmers. A pecuniary stimulus would thus also be given. To the neighbouring farmer or landholder these lists would be invaluable; they would show him where to apply with the best

chance of success for compensation for proved loss by noxious vapours; or enable him to apportion his claim among several works, in proportion to their places in the list and their relative distance from his land.

Thus in place of the goading influence of a few isolated and sudden prosecutions, a gradual pressure onwards would be felt, a constant stimulus to improvement. All chemical manufactures cannot be embraced in the provisions of an extended Alkali Act until for each separate noxious vapour a process of suppression can be described, and a limit for its working defined. But with such an arrangement as is here proposed, all noxious vapours without the task of enumeration would be at once legislated for. If there are several manufacturers carrying on the same processes in the same district, and one of them by special ingenuity discovers some process by which a large portion of the acid vapour he has hitherto sent away may be condensed, he improves his place in the *list*, and so enjoys immunity from actions for damage on the part of the farmers. The other manufacturers would obviously be compelled to follow him in the race of improvement. Thus all would be brought up to the rank of the foremost, and there would be a constant impulse to the manufacturer to reduce the noxious emanations from his works within the smallest possible amount.

V. DE MORTUIS.

By Henry Woodward, F.G.S., F.Z.S., &c.

In almost all countries, both among savage and civilized races, the rites of sepulture have been looked upon as a debt so sacred that those who neglected it were considered infamous.

The Greeks and Romans believed so strongly in the importance of this obligation that they considered it to be fatal to their admission into *Elysium* to neglect to do honour to the dead.

Nor can the practice of honouring the dead be claimed by these classical countries alone, for throughout Egypt, Palestine, Persia, India, and China, are monuments of the most lasting and costly description raised to the mighty dead.

That the more northern and western races of mankind possessed the same traditions cannot be doubted, and although their monuments are of a ruder character they display often a vast amount of labour in their construction, and an equal care for the departed whose remains they were intended to preserve.

On the rude but colossal "Megalithic Structures of the Channel Islands, their History and Analogues," a very able and exhaustive

article by Lieut. S. P. Oliver, Royal Artillery, F.R.S., appeared in the 'Quarterly Journal of Science' for April last, to which it is only needful here to refer our readers.*

Fortunately for the archæologist the uninviting exterior of these northern and western tombs has been, until of late years, a means of protecting them to a great extent from pillage; for within these rounded dome-like hills of earth (Tumuli) are often discovered relics of a period so remote that, save for these sacred depositories, we never could have hoped to obtain any reliable information of the builders, or to have learnt aught of their advance in civilization, or of the arts they practised.

The rich and varied discoveries of the Swiss Lake habitations indeed, have thrown much new light upon the early history of Europe, yet many writers have nevertheless concluded that these remains are, after all, not much more than two thousand years old, seeing that similar lacustrine habitations were known to Hippocrates (B.C. 460), and Herodotus (B.C. 404). But the careful researches of Prof. Keller, and many other investigators, prove beyond question that these settlements go back to the early Neolithic period, if not to the palæolithic.

In speaking of the ages of Stone, Bronze, and Iron, however, we should always guard against the notion that, at any one time, save in the very earliest palæolithic stage, one material for the manufacture of implements was used exclusively over the whole of the Continent. Not only does the "Iron age" stretch from our own time back to an antiquity more remote than Nineveh, but the "*Bone* age" is still extant and has overlapped all the other divisions, for horn and bone are still used by civilized man, and our most remote ancestors we know discovered the economic value of the bones and horns of the first animals they slew in the chase.

Therefore in the examination of all early remains many collateral circumstances must be taken into account before we can justly assign an approximate date to any discovery. For instance, if we grant that the civilization of man actually ran its course through these periods, just as they are mentioned above, yet it is certain that the Bronze period of Northern Europe by no means agrees in time with that of the middle and southern parts of this Continent.

Again, the Bronze age of Greece and Italy may be separated by centuries from that of Egypt, which we may consider as the cradle of western civilization.

We may safely conclude, as the Danish antiquaries themselves allow, that in the Scandinavian countries stone implements were for a length of time used while the Bronze period was in full activity in the more southern lands, and that Egypt, whose oldest monuments indicate very clearly the use of iron, and also Greece, had both ad-

* Vol. vii., p. 149.

vanced to the Iron period when Central Europe was in the Bronze age. If, therefore, according to the testimony of ancient authors and monuments, bronze and iron were used in the earliest ages in the countries round the shores of the Mediterranean, the commencement of these periods in the inland and northern parts of Europe was regulated entirely by the greater or less amount of intercourse between these countries and those to whom we are indebted for a knowledge of metals, so essential to civilization. We may even at the present day observe a similar irregularity in the distribution of the products of higher civilization and art. Nor do these divisions give us any positive certainty; for in very few burial places or early settlements are the remains found so purely distinctive as to enable us conclusively to attribute them to any one of the three periods.

It seems very certain that there was no hard line of demarcation between the three periods, but that the new materials were spread abroad like any other article of trade, and that the more useful tools gradually superseded those of less value.*

We should hardly, writes Sir John Lubbock,† have hoped to ascertain much of the manner in which the people of the Bronze age were dressed. Considering how perishable are the materials out of which clothes are necessarily formed, it is wonderful that any fragments of them should have remained to the present day. There can be little doubt that the skins of animals were extensively used for this purpose, as indeed they have been in all ages of man's history; many traces of linen tissue also have been found in English tumuli of the Bronze age and in the Swiss lakes. Even a single fragment throws much light on the manufactures, if we may call them so, of the period to which it belongs; but fortunately we need not content ourselves with any such partial knowledge as this, as we possess the whole dress of a chief belonging to the Bronze age.

On a farm occupied by M. Dahls, near Ribe, in Jutland, are four tumuli, known as Great Kongehoi, Little Kongehoi, Guldhoi, and Treenhoi. This last was examined in 1861 by MM. Worsaae and Herbst. It is about 50 ells in diameter and 6 in height, being composed of a loose sandy earth. In it, near the centre, were found three wooden coffins, two of full size, and one evidently intended for a child. The coffin with which we are now particularly concerned was about 9 feet 8 inches long and 2 feet 2 inches broad on the outside; its internal measurements were 7½ feet long and 1 feet 8 inches broad. It was covered by a movable lid of corresponding size. The contents were peculiar and very interesting.

While, as might naturally be expected, we find in most ancient graves only the bones and teeth, all the soft parts having long ago decayed away, in some cases—and this was one of them—almost

* Keller's 'Lake-Dwellings:' translated by J. E. Lee, F.S.A.
† 'Pre-historic Times.'

exactly the reverse had happened. Owing to the presence of water, and perhaps to the fact that it was strongly impregnated with iron, the soft parts of the body had been turned into a dark, greasy, substance (*adipocere?*); and the bones, with the exception of a few fragments, were changed into a kind of powder.

Singularly enough, the brain seems to have been the part which had undergone the least change. On opening the coffin it was found lying at one end, where no doubt the head had originally been placed, covered by a thick hemispherical woollen cap, about 6 inches in height. The outer side of the cap was thickly covered by short loose threads, every one of them ending in a small knot, which gave the cap a very singular appearance. The trunk of the corpse had been wrapped in a coarse woollen cloak, which was almost semicircular, and hollowed out round the neck. It was about 3 feet 8 inches long, and broad in proportion. On its inner side were left hanging a great number of short woollen threads, which gave it somewhat the appearance of plush. On the right side of the corpse was a box, closed by a lid, 7½ inches in diameter, 6¼ inches high, and fastened together by pieces of osier or bark. In this box was a similar smaller one, without a lid, containing three articles, namely, a cap 7 inches high, of simply woven woollen stuff; a small comb, 3 inches long by 2½ inches high; and a small simple razor-knife. The coffin also contained two woollen shawls, one of them covering the feet, the other lying higher up; they were square in shape, 5 feet long, 3 feet 9 inches broad, and with a long fringe.

At the place where the body had lain was a shirt, also of woollen material, cut out a little for the neck, and with a long projecting tongue at one of the upper angles. It was fastened at the waist by a long woollen band, which went twice round the body, and hung down in front. On the left side of the corpse was a bronze sword in a wooden sheath, 2 feet 3 inches in length, having a solid simple handle. At the feet were two pieces of woollen stuff about 14½ inches long and 3½ inches wide, the use of which does not seem quite clear, though they may be supposed to be the remains of leggings. At the end of the coffin were found traces of leather, doubtless the remains of boots. In the cap where the head had been was some black hair, and the form of the brain was still recognizable. Finally, this ancient warrior had been wrapped round in an ox's hide, and so committed to the grave. The other two coffins were not examined by competent persons, and the valuable information which they might have afforded is lost to us. The more indestructible things were, however, preserved; they consisted of a sword, a brooch, a knife, a double-pointed awl, a pair of tweezers, a large double button or stud, all of bronze; a small double button of tin, and a javelin-head of flint.

The "Kongehoi" contained four wooden coffins, in which were bodies clothed in woollen garments, a bronze sword in a wooden sheath ornamented with carvings, two bronze daggers, a wooden bowl ornamented by a large number of tin nails, a vase of wood, and a small box of bark.

There can, therefore, be no doubt that these very interesting tumuli belonged to the Bronze age, and I am inclined (says Sir John Lubbock) to place them somewhat late in the period, partly on account of the knife and razor-knife, both of which are forms referable to the close of the Bronze period, and to the beginning of that of Iron. Bronze brooches are also very rarely found in the Bronze age, and are common in that of Iron. The sword, again, belongs to a form which Professor Nilsson regarded as being of late introduction. The mode of interment may also be regarded as unusual in the Bronze age, though commonly so found in interments of the Iron age.

In Denmark cremation appears to have been all but universal, and seems plainly to betoken the south-eastern origin of the peoples who practised it. Bateman and Sir R. C. Hoare, record a number of instances of graves opened by them in England containing objects in bronze which well illustrate the prevalence of burning the dead:—

	Body contracted.	Burnt.	Extended.	Position uncertain.
Number of cases..	19	59	7	15

Canon Greenwell also mentions that out of 100 interments with bronze ornaments, &c., examined by him, all were either burnt or the body was placed in a sitting posture. Of the wide-spread practice of interment in a sitting posture, we may find abundant instances in Wilson's 'Pre-historic Man.' Thus * in opening a Peruvian tomb it is stated "the male mummy was that of a man in the maturity of life, *in the usual sitting position*, with the knees drawn up to the chin." We should certainly consider this mode of interment to be the most primitive.

If ornaments, weapons, or coins in any number, be found in the grave, or if much labour has been bestowed upon its construction, we may justly infer that, to whatever period the grave may belong, it was the last resting-place of a chief or warrior of the tribe; for the same causes which operate now to deter the poorer classes from a lavish expenditure upon the dead, acted in early times still more strongly, when every article of dress and every weapon being required for daily use were of so much greater intrinsic value, and consequently the devotion which instigated their dedication to the use of the departed must have been either the result of strong attachment, or a display of the affluence of the family to which the deceased belonged.

There can be no doubt that the introduction of Christianity was

* At p. 440.

the means, not only of putting an end entirely to the practice of incremation, but also to a great extent to that of depositing votive offerings in the graves of the departed. The introduction of such sentences as those which our burial-service contains, against the thought that we can take anything with us out of the world, evidently when introduced by the early Church had reference to the heathen practice of placing objects highly esteemed in the grave with the dead.*

Schiller's lines (translated by Lytton) well express this practice so common among the aborigines of our own day:—

> "Here bring the last gifts! and with these
> The last lament be said;
> Let all that pleased, and yet may please,
> Be buried with the dead.
>
> Beneath his head the hatchet hide
> That he so stoutly swung;
> And place the bear's fat haunch beside—
> The journey hence is long!
>
> And let the knife new sharpened be
> That on the battle-day
> Shore with quick strokes—he took but three—
> The foeman's scalp away!
>
> The paints that warriors love to use,
> Place here within his hand,
> That he may shine with ruddy hues
> Amidst the spirit-land."

It not unfrequently happens that fragments of the bones of sheep and other animals are found in cinerary urns associated with the human remains. This is easily explained when we consider the manner in which the rites to the dead were performed.

If the dead person were a chief or warrior of note, it was usual to erect a funeral-pyre of great size, upon which the corpse was laid, surrounded by the bodies of various animals slain in honour of the dead, together with costly unguents and perfumes. Frequently a number of slaves and captives were also sacrificed to the *manes* of the departed. Thus, in Homer's 'Iliad,' we have a graphic description of the death of Patroclus during the Trojan war, and the honours paid to his body by Achilles and the Greeks:—

> "While those deputed to inter the slain
> Heap with a rising pyramid the plain.
> A hundred feet in length, a hundred wide,
> The growing structure spreads on every side;
> High on the top the manly corse they lay,
> And well-fed sheep and sable oxen slay:
> Achilles covered with their fat the dead,
> And the pil'd victims round the body spread;

* Rolleston 'Archæologia,' vol. xlii.

Then jars of honey, and of fragrant oil,
Suspends around, low-bending o'er the pile.
Four sprightly coursers, with a deadly groan
Pour forth their lives, and on the pyre are thrown.
Of nine large dogs, domestic at his board,
Fall two, selected to attend their lord.
Then last of all, and horrible to tell,
Sad sacrifice! twelve Trojan captives fell.
On these the rage of fire victorious preys,
Involves and joins them in one common blaze."*

During the ceremony, decursions and games were celebrated, often lasting several days, after which the *ossilegium*, or gathering of the bones and ashes of the dead, washing, anointing, and depositing in urns, was performed.

Amongst refined and civilized peoples it is possible to conceive that a certain sacredness was connected with this ceremonial, and that such lines as the *Salve Eternum* might form an appropriate conclusion of such service:—

"Farewell, O soul departed!
Farewell, O sacred urn!
Bereaved and broken-hearted,
To earth the mourners turn!
To the dim and dreary shore,
Thou art gone our steps before!
But thither the swift hours lead us,
And thou dost but awhile precede us!
Salve—Salve!
Loved urn and thou solemn cell,
Mute ashes!—farewell, farewell!
Salve—Salve!"†

But the incremation ceremony in western and northern Europe was in reality more an occasion of feasting; the slain animals being chiefly cooked and eaten by the mourners. Thus we find in Anglo-Saxon barrows and graves in England abundant remains of animals, especially those of the horse, which have served as feasts.

To so high a pitch had this practice of the lyke-wake risen in later times that it was severely denounced in numerous inhibitions issued by the early Church.‡

Judging by the number of instances in which gold ornaments have been found in graves, it seems probable that gold was the metal which first attracted the attention of man. Its bright colour would certainly attract even the rudest savages, who are known to be very fond of personal decoration.

Silver does not appear to have been discovered until long after gold, and was apparently preceded by both copper and tin, as it is rarely, if ever, found in tumuli of the Bronze age; but however this may be, copper seems to have been the metal which first became of real importance to man; no doubt owing to the fact that its ores

* Pope's Translation of the 'Iliad,' Book xxiii.
† 'Last Days of Pompeii:' Lytton.
‡ See Rolleston in 'Archæologia,' vol. xlii.

are abundant in many countries, and can be smelted without difficulty; and that, while iron is hardly ever found except in the form of ore, copper often occurs in a native condition and can be beaten at once into shape.*

There is no reason to suppose that the mound-builders, whose earth-works occupy leagues in extent in the valleys of the Mississippi and Ohio, were acquainted with the art of smelting copper; that they mined it extensively on the shores of Lake Superior, and wrought it into knives, spear-heads, chisels, and bracelets, and other personal ornaments there can be no reasonable doubt, but having no tin, they could not, like the ancient dwellers of the Swiss lakes, Denmark, &c., impart to the alloy almost the hardness of steel. It is doubtful, even, whether their metallurgic art extended to the smelting of copper; for it often happens that the native copper of Lake Superior encloses native silver, both metals existing side by side chemically pure, which, if smelted, in whatever proportions, would form a homogeneous compound. Bracelets have been found in the mounds, in which this peculiarity is preserved, thus showing that the material had not been smelted but simply hammered cold; and the ends are brought together by bending, without any evidence of having been soldered.†

Of the amount of gold found in the Chiriqui graves in Central America probably no just estimate can be obtained. At the period of Mr. Power's visit in August, 1859, about 250 lbs. weight of gold had been extracted from the *huacas* at Bugábita, two-thirds being tolerably pure gold, the remaining third what is called "guanin," or gold alloyed with copper; the value of the whole was about 12,500*l*. In the summer of 1861, some fresh tombs were discovered from which gold objects to the value of 16,000*l*. had been extracted.‡ Although, as must necessarily happen, these interesting remains find their fate in the melting-pot wholesale, there are yet to be seen in the Blackmore Museum at Salisbury, the Christy Museum, Victoria Street, the British Museum, and elsewhere, many examples of these curious American antiquities.

From a careful examination of many of the Ohio mounds and a comparison of their characteristics with ancient Scandinavian tumuli, it seems highly probable that, in some instances at least, the tomb was formed by covering the dwelling in which the dead man had lived with a mound of earth or a cairn of stones.

This would explain the curious sorted condition of many remains in the American mounds. Thus in mound No. 8, "Mound City," may have been buried the body of some celebrated pipe-maker, with all his stock-in-trade, which his friends no doubt believed he would

* Lubbock, 'Pre-historic Times,' pp. 3–4.
† Foster's 'Mississippi Valley,' p. 423.
‡ 'Flint Chips,' by E. T. Stevens, pp. 285–6.

find valuable to him for barter in the land of spirits as he had done in this world. In others the stock of arrow-heads was so enormous we may well suppose the occupier of the mound had been a maker of flint arrow-heads.

The practices of modern savages often throw great light upon these difficult points.

Thus we find among the New Zealanders, if the owner dies, he is commonly buried in his house with all it contained.* The islanders of Torres Straits also used their dwelling-huts as dead-houses.† It is still more significant that the Esquimaux themselves frequently leave the dead in the houses which they occupied when alive.‡ We cannot, says Sir John Lubbock, compare the plan of a Scandinavian "passage-grave" with that of an Esquimaux snow-house, without being struck with the great similarity existing between them.

Under these circumstances there seems much probability in the view advocated by Professor Nilsson, the venerable archæologist of Sweden, that these "passage-graves" are a copy or adaptation of the dwelling-house; that the ancient inhabitants of Scandinavia, unable to imagine a future altogether different from the present, or a world quite unlike our own, showed their respect and affection for the dead by burying with them those things which in life they had valued most; with women their ornaments, with warriors their weapons.

They buried the house with its owner, and the grave was literally the dwelling of the dead.§

From the foregoing premises we may venture to establish this axiom, namely, that any people who accompanied the rites of interment of their dead by such evident indications of care and attention as we find in a vast number of graves belonging to different periods and races in Western Europe and America, may be safely concluded to have possessed a notion of a future state, whatever may have been the name they ascribed to it; and moreover they must have also believed it possible, by their gifts and good offices, to assist their departed friends into the spirit land.

* Tylor, 'New Zealand and its Inhabitants,' p. 101.
† M'Gillivray, 'Voyage of Rattle-snake,' vol. ii., p. 48.
‡ Ross' 'Arctic Expedition,' 1829–33, p. 290.
§ Lubbock, 'Pre-historic Times,' pp. 126–7.

VI. FOREIGN TREES AND PLANTS FOR ENGLISH GARDENS.*

By Alfred W. Bennett, M.A., B.Sc., F.L.S.

The introduction of new forms of vegetable life into our gardens and greenhouses has made considerable progress during recent years. The Acclimatisation Societies of Paris and London have, it is true, paid more attention to the domestication of foreign animals than of plants; something, however, has been attempted in this direction, and with considerable success. This branch of acclimatisation would, indeed, seem likely to be the most fertile in results beneficial to mankind. For one fresh animal introduced that will be of real utility, there will probably be a dozen plants that yield important economical products. The early races of mankind appear to have exhausted our powers over the lower animals—the horse, the ass, the dog, the camel, the ox, the sheep, were all brought under subjection to man at the earliest period of his history; and within historic times no important addition has been made to the number of our domestic animals. Not so with plants. A large number of the vegetable substances used as food at the present day, and of the vegetable articles of manufacture, were unknown to the ancients; and the field for further extension of our utilisation of the vegetable kingdom seems indefinitely large. The power of cultivation in modifying plants is also much greater than any corresponding power of domestication in modifying animals. The oldest extant drawings of the horse, the ox, or the camel, scarcely point out any distinctive features from their descendants now living; the potato and the apple, on the other hand, may almost be considered as manufactured products; while many gardeners' flowers, such as the Pelargonium and the Tulip, differ so widely from their ancestors as, in some cases, to obscure their parentage. The term Acclimatisation has been objected to by some scientific men, on the ground that the descendants of any animal or plant which has been transported from one climate to another have no more power than their ancestor of adapting themselves to that climate, unless the principle of Natural Selection has come into play to eliminate the individuals least able to adapt themselves to the new climate, those only surviving which, from some cause or other, are most suited to the fresh conditions. Be this as it may, there is no question about the fact that the farmer

* 'The Planter's Guide: Trees and Shrubs for English Plantations.' By A. Mongredien. London: J. Murray. 1870.

'Alpine Flowers for English Gardens.' By W. Robinson, F.L.S. London: J. Murray. 1870.

'Dendrologie: Bäume, Sträucher, und Halb-sträucher welche in Mittel oder Nord-Europa im Freien kultivirt werden.' Kritisch bearbeitet von Karl Koch. Erster Theil. Erlangen. Enke, 1869.

and the gardener have it in their power to naturalise plants foreign to our climate and our soil.

But the conditions of this naturalisation are by no means so simple as might at first sight appear. It might naturally be supposed that all we have to do is to introduce those plants which grow spontaneously in a climate and a soil similar to our own, and that they will necessarily flourish, and will scarcely be aware of the change. Or, if they come from a warmer country, that all that is needed is to protect them by glass and artificial warmth from the inclemency of our winters. But in practice this is not found to be the case. A plant will frequently obstinately refuse to become naturalised in a country, the climatal and geological conditions of which are similar to those that occur in the region where it is indigenous. Our common daisy, a native of almost every country of Europe, is said to have resisted all attempts to introduce it even into the gardens of the United States. Some plants seem to have an unconquerable aversion to the fostering hand of man, even in their own country. A well-constructed and carefully-kept fernery will contain specimens, more or less luxuriant, of nearly all our native ferns; the polypody and hartstongue from shady banks and tree-stumps; the so-called male and female ferns from the woods; the spleenwort from dry walls; even the royal "flowering-fern" from bogs; and some of the semi-alpine species will flourish with the exercise of a little care. One kind, however, is almost invariably absent, and that the most widely distributed of all our ferns, the common brake, a native of every county and almost of every parish in the country, but which can seldom be induced to remain a denizen of soil that has once been brought under man's dominion. On the other hand, some of the greatest favourites of our gardens, which display no coyness whatever in over-running our flower-beds, are natives of countries where the climate presents very different features to our own, or of very limited tracts of our own country, to which they seem strictly confined by impassable barriers of soil or meteorological conditions. To take instances of the latter phenomenon:—There is no garden flower more cosmopolitan in its tastes, more certain to thrive under any conditions of light or heavy soil, sun or shade, care or neglect, even in the heart of a town, as its very name seems to indicate, than the London Pride. Yet the *Saxifraga umbrosa* is one of the most restricted in distribution of our native plants. Abundant enough where it does grow, it is yet entirely confined to the moist equable climate of the hilly country in the south-west of Ireland and a few other similar localities, beyond which it is never found in the wild state. Botanists will think themselves amply repaid for a toilsome day's march by gathering the beautiful *Polemonium cæruleum* in its native habitat among the calcareous hills of the west of Yorkshire; yet the Jacob's Ladder is an ornament of every garden on the very

stiffest part of the London clay. Probably every piece of cultivated ground, which contains a laburnum tree, produces each spring a plentiful crop of self-sown young trees, which come up without the least care or protection until destroyed in the process of weeding; yet the laburnum shows no disposition to take a place among the naturalised trees of our woods and hedges, although the seeds must often be carried there by birds. It is remarkable that many of our common vegetables, the cabbage, the asparagus, the sea-kale, the celery, are natives of our own shores, never growing spontaneously out of reach of the salt spray; and yet requiring, when transplanted into our gardens, no peculiarity of soil or treatment to enable them to support a vigorous existence. These are instances of plants to which our climate appears entirely congenial, and yet which seem as if they could not propagate themselves with us or spread, except under man's protection. Others, again, appear to require only to get a footing in a foreign soil to become established in it with extraordinary rapidity, even to the overmastering or expulsion of some of the indigenous inhabitants. When Australia and New Zealand were first colonized by Europeans, their flora presented an aspect of perfect strangeness, very few of the native trees or flowers belonging even to genera common to Europe. The seeds of some of our English weeds were, however, introduced, intentionally or accidentally, by the early settlers; and now the thistle covers the waste lands of Australia as it does in England, and the clover and the groundsel everywhere remind the Englishman of his far-away home, and have become as completely at home as the mustangs or wild-horses on the pampas of South America. In our own country a very remarkable instance of this rapid naturalisation has occurred in the case of the *Elodea canadensis* or Canadian water-weed; which, introduced not many years since into our canals from Canada, has now become such a pest in many places as seriously to impede the navigation. Other instances might be mentioned of foreign plants introduced with seed having in a very short time become common weeds in all cultivated land. Indeed, many of the species included in our handbooks of British plants are so entirely confined to arable land or to spots in the immediate vicinity of human dwellings, that it is impossible to say how many of them may be really indigenous to the soil, and how many naturalised aliens.

There is no doubt we have a great deal to learn as to the mode in which plants propagate themselves in nature, which may be of the utmost value to our gardeners. Every one is familiar with the fact of the apparently spontaneous appearance, in immense abundance, of plants in soil when subjected to certain farming operations, or on the sowing of some particular crop. Whenever a new railway cutting or embankment is made, some plant unknown in the neighbourhood is almost sure to appear, and either permanently

establish itself or again disappear after a few years. The "sowing" of land with lime is invariably followed by the appearance of a crop of white or Dutch clover. When certain kinds of wood are cut down, it is said that during the next year a particular species of moss will always be found covering the ground. Immediately after the great fire of London in 1666, the London Rocket (*Sisymbrium Irio*) sprang up in enormous quantities on the dismantled walls, but is now no longer to be found in the metropolitan district. The usual theory to account for this sudden appearance of new plants is the existence in the soil of large "stores of seeds" ready to germinate on the first favourable opportunity. In his Anniversary Address to the Linnean Society in 1869, Mr. Bentham, however, pointed out that if this explanation is the true one, it ought not to depend merely on theory, but would be capable of easy practical verification. He suggested whether a hitherto insufficiently acknowledged part in the rapid dissemination of plants may not be played by birds. The whole subject presents a wide field for further investigation, and must amply reward any one who takes up the inquiry, if endowed with the qualities of accurate observation and patient research.

Mr. Mongredien's 'Planter's Guide' deals chiefly with the introduction into this country of foreign trees and shrubs. Within the last twenty or thirty years the appearance of our lawns and plantations has been greatly changed by the number of new forms which have made their appearance. The stately *Wellingtonia*, the formal self-asserting "Puzzle-monkey" or *Araucaria imbricata*, the massive Deodar and *Cryptomeria*, the elegant *Pinus insignis* and *Cupressus Lawsoniana*, are all still of too recent introduction to permit us to judge of what their effect will be when grown to their full stature. The number of cone-bearing trees from all parts of the world, perfectly hardy in this climate, is extraordinary; and, partly from their graceful shape, partly from the evergreen character of their leaves, the attention of cultivators has been perhaps too exclusively confined to them, while deciduous trees have been comparatively neglected. Recent experiments have shown that in this quarter also there is abundant room for an extension of our powers of domestication. In one of the London Parks least frequented by the upper ten thousand, that at Battersea, great success has attended the introduction, during the last few years, of half-hardy trees and shrubs, the precaution being taken of protecting their roots during winter by a layer of some substance impervious to frost. The French have paid more attention to the perfect naturalisation of half-hardy plants than we have done: notwithstanding the greater severity of their winter, species are grown by them out of doors which are never seen with us except in greenhouses; even as far north as Paris, the bamboo, for instance, is frequently met with in

gentlemen's gardens; and there is no doubt that many shrubs and herbaceous plants, which we never think of attempting to grow except under protection, might, with a very little care and attention, become permanent denizens of our gardens and shrubberies. Probably few are aware that the common Camellia will stand with impunity an ordinary English winter. Mr. Mongredien says that "if protected during the first two or three years after being planted out, and when once established, it proves in the climate of London quite as hardy as the common laurel, and blooms as profusely as in a conservatory. It is true that, from its habit of flowering early in the spring, the blossoms are sometimes damaged by the nipping easterly winds, but this occurs only in unfavourable seasons; and even if the tree never flowered at all, its lovely foliage would still make it one of the most beautiful evergreens of which our gardens can boast. A plant of the variety *Donkelarii* has stood out for twelve years in a garden at Forest Hill with a northern aspect, without the slightest protection during the severest winters, and now forms a good-sized bush, densely clothed with magnificent foliage. The Camellia ought to be planted out in every garden, and with a little attention for the first year or two, it would prove quite hardy, at least in the more southern counties, and each season it would increase in attractiveness."

The climate of the south of England is far more congenial to the introduction of foreign trees and shrubs than that of the northern counties, not from the greater severity of the winters in the north, for the minimum temperature of the year is often as low in Kent or Hampshire as in Yorkshire or Northumberland, but from the shorter and cooler summers. Many plants absolutely require a considerable period of high temperature to enable them to ripen their wood sufficiently to withstand the winter frosts, and especially to induce them to flower. In many parts of Scotland, however, the climate is as favourable to horticulturists as in any district of England. In the Duke of Sutherland's estate at Dunrobin, on the east coast of Sutherlandshire, Hydrangeas, myrtles, and other half-hardy plants, grow as freely and as unchecked out of doors as they do in Devonshire or Cornwall. The equalizing effect of the Gulf Stream on the temperature is no doubt the cause of this special immunity from frost. The proximity of the sea-coast is not generally favourable to the growth of trees and shrubs, not so much from the saltness of the air as from the prevalence of high winds, which are very injurious to growing vegetation. Young and tender shoots which will bear a moderate amount of cold, will sometimes be scorched as if by fire by a tempestuous night.

Mr. Mongredien's book is intended as a repertorium of everything connected with the choosing, planting, and treatment of English and foreign trees and shrubs, and contains an immense mass

of information for any one whose tastes lie in this direction. Its defects are rather of omission than of commission. The plan promises a completely exhaustive treatment of the subject: in the first place we have an alphabetical list, with brief descriptions, of 621 trees and shrubs, selected as desirable for planting in the open air in this country; followed by a classification of them under a variety of headings, as to their height, their foliage, their time of flowering, the colour of their flowers, their fruit, their timber, and other points. It is illustrated by a number of very pretty woodcuts, of which we subjoin a specimen. The principle on which these 621 species

Abies nobilis; Wimbledon.

have been selected is not always obvious. Why, for instance, is our common Fuchsia (miscalled *Fuchsia coccinea*, as Dr. Hooker has shown) excluded, forming as it does the glory of every cottage-garden in the Isle of Wight and in Devonshire, the stems assuming almost

a tree-like character; or the *Berberis aquifolium*, which, with its glossy leaves and very early flowers, is so deservedly a favourite in every shrubbery? In the enumeration of winter-flowering plants we miss also the beautiful *Forsythia*, and several others which might have been mentioned. An exceedingly useful list is that of "species which thrive in the smoke of cities," in which Mr. Mongredien names the horse-chestnut, *Ailantus glandulosa*, Virginian creeper, almond, *Artemisia abrotanum*, Aucuba, Catalpa, *Cydonia japonica*, laburnum, fig, ivy, Cape jasmine, privet, *Paulownia imperialis*, *Phillyrea media*, plane, evergreen oak, *Rhamnus Alaternus*, sumach, flowering currant, *Robinia pseudacacia* (commonly called the acacia), *Sophora japonica*, and guelder rose; a very useful list to cultivators of suburban gardens, but again very incomplete. In London gardens the lilac is everywhere the companion of the laburnum; magnificent hawthorn-trees could be shown within two miles of Charing Cross; the roads in the suburbs are everywhere adorned in early spring with the beautiful light-green foliage of the lime; while the sides of the houses are gay in the summer with the gorgeous flowers of the hardy passion-flower, or the gigantic leaves of the *Aristolochia Sipho*; nor should the apple, the pear, and the cherry have been omitted, if it is only for the wealth of their flowers. It is worthy of remark that the smoke of an ordinary town is not nearly so destructive to vegetation as that poured forth from the chimneys of manufactories or chemical works. Flowers will be found to thrive in gardens in the very heart of London, which many a Lancashire gentleman would give almost any money to establish even in his greenhouses. Notwithstanding the deficiencies we have named, 'The Planter's Guide' is a book that should be in the hands of every one interested in the subject; and we hope it may be the means of attracting attention to the great value and importance of ornamental planting in improving the character of our lawns, shrubberies, and parks.

If we now turn from trees and shrubs to herbaceous plants, we enter on a still wider field, and one more within the reach of every lover of nature. Arboriculture, after all, must always be the pursuit of those only who have both money and space at their command; floriculture may be followed by every cottager, and even by every dweller in a town who has a window-sill at his disposal; and we doubt whether the latter does not derive the most pleasure from it. Although many of the favourite flowers of the last two or three generations will probably always hold a place in our gardens, and deservedly, yet the number of species that have been introduced of late years worth cultivating for their beauty, and within the reach of every one who possesses a flower-pot, is very large; and as a hand-book for this class of plants, though treating only of a section of them, plants especially adapted for rock-work, we can most

cordially recommend Mr. Robinson's 'Alpine Flowers for English Gardens.' The easy and lively style in which it is written, no less than the excellence of its matter, will commend it to every lover of plants.

Mr. Robinson is no mere enthusiast in his subject when he says:—"This book is written to dispel a very general error, that the exquisite flowers of alpine countries cannot be grown in gardens, and as one of a series of manuals having for their object the improvement of our out-door gardening, which, it appears to me, is of infinitely greater importance than anything that can ever be accomplished in enclosed structures, even if glass sheds or glass palaces were within the reach of all." His first concern is with the structure of rockeries, in the mode of building which not only is the taste still displayed, or at all events till quite recently, barbarous and inartistic in the extreme; but it would seem as if the very conditions necessary for the health of the plants were studiously neglected. The ordinary idea of the treatment of rock-plants, judging from the hideous monstrosities which may be seen in many a gentleman's garden, is that you have nothing to do but to poke them in between the chinks of perfectly bare stones or clinkers piled together in a promiscuous heap, in order to present them in their native habitats. A gardener who commits such an absurdity as this, can never have ascended a mountain with his eyes open. To quote again from Mr. Robinson:—"Mountains are often bare, and cliffs are usually devoid of soil; but we must not conclude therefrom that the choice jewellery of plant-life scattered over the ribs of the mountain, or the interstices of the crag, live upon little more than the mountain air and the melting snow! Where will you find such a depth of well-ground stony soil, and withal such perfect drainage, as on the ridges of *débris* flanking some great glacier, stained all over with tufts of crimson saxifrage? Can you gauge the depth of that narrow chink, from which peep tufts of the diminutive and beautiful *Androsace helvetica?* No; it has gathered the crumbling grit and scanty soil for ages and ages; and the roots enter so far that nothing the tourist carries with him can bring out enough of them to enable the plant to live elsewhere." Alpine plants are peculiarly exposed to sudden alternations of heat and cold, of moisture and dryness. The cold, almost frosty night will be followed, in July and August, by an unclouded day, when the rays of the sun beat on the unsheltered surface of the rock with an intensity that would scorch up many an English meadow plant. Only a very small proportion of alpine plants are annuals; and they are frequently provided with a storehouse of nourishment in the form of rosettes or tufts of thick succulent leaves; but their chief water-supply is through their roots; and thus we find that while our garden annuals have fibrous roots of insignificant dimensions, and even

our forest trees will seldom strike their roots to a greater depth than the height of their foliage, the roots of alpine plants scarcely an inch in height will be found to penetrate the chinks between the rocks full of rich earth, to the depth of sometimes more than a yard, or forty times the height that they venture into the air. The neglect of this most essential condition for the growth of alpine plants is of itself amply sufficient to account for the failure which has generally accompanied the attempts to introduce these lovely flowers to our rockeries. A good depth of soil is indeed more indispensable to these plants than the presence of rock and stone. They no doubt prefer to expand their flowers and extend their green shoots over the bare rock; and where rock-work is artistically managed, this faint attempt at a reconstruction of their native habitat adds greatly to the picturesqueness of the effect. But many of them will flourish equally well in open borders, and even when planted in pots, with a few stones about them to protect the roots from the direct action of the sun, if only the two requisites are attended to, of constant moisture and perfect drainage; and hence they are invaluable acquisitions to the cottage or window gardener. The Saxifrages, the beautiful purple *Aubrietia*, with respect to which Mr. Robinson says, "rock-works, ruins, stony places, sloping banks, and rootwork suit it perfectly; no plant is so easily established in such places, nor will any other alpine plant clothe them so quickly with the desired vegetation," the various species of Arabis, the alpine Primulas, all make excellent bedding plants. The ease with which a new alpine can be domesticated in our climate is shown by the rapid spread of the lovely early forget-me-not, *Myosotis dissitiflora*, brought not many years since from the Alps near the Vogelberg, now to be had from every nurseryman, and the treasure of many a cottage garden, with its exquisite sky-blue flowers, continuing from mid-winter till early summer.

But it is not alpine flowers only which will repay the small amount of trouble necessary for their introduction. Many plants which are never grown without the protection of a greenhouse, do not require any elevation of temperature for their successful growth, but merely an absence of great changes both of temperature and moisture. This is especially the case with not a few of the most delicate ferns, such as the elegant maidenhair, and the two fragile little filmy-ferns; and the requisite uniformity of temperature and moisture can be obtained out of doors by the erection of a partially underground grotto or ravine of rocks, through which water is perpetually trickling, the entrance being protected by a screen of foliage from the direct influence of the weather. It is astonishing how equable a climate can be obtained by a simple device of this kind. The drawing given on p. 359 is from such a rock-cave constructed in the grounds of one of our most scientific and success-

ful nurserymen near York, where he grows not only our royal so-called "flowering fern," the *Osmunda regalis*, and several foreign

Entrance to Cave for Killarney Fern in Rock-garden.

allied species, but the most beautiful of all this beautiful tribe, the moisture-loving Killarney fern, which clothes the soil of the damp dark woods by the Torc waterfall.

The beauty of these horticultural experiments is that they can be tried on so small a scale, and are thus within the reach of almost every one; yielding a source of pure and healthy enjoyment which few other pursuits will afford. Mr. Robinson almost promises us that his little book shall be the first of a series of similar manuals on different departments of gardening; and we can hardly conceive a greater service than this to a large number of his countrymen, who merely require to be told how to set to work to cultivate this fascinating science.

VII. A RECENT TRIUMPH OF SYNTHETICAL CHEMISTRY.

It is not often that so legitimate a triumph of synthetical chemistry as the artificial production of a natural substance becomes, at the same time, an important national discovery, the money value of which may be reckoned by millions. Such, without exaggeration, it is not unlikely that the artificial production of Alizarine, the colouring matter of madder, may become.

Madder is the root of a plant belonging to the order of *Rubiaceæ*, amongst which are included some valuable plants, such as the cinchona, ipecacuanha, and coffee. The madder plant is the *rubia tinctorum*. It is estimated that its consumption reaches over 47,000 tons per annum, and this, at 45*l*. per ton, amounts to over 2,000,000*l*. sterling, one half of which is imported to England, and the payment for which (1,000,000*l*.) goes out of this country into the pockets of foreign manufacturers. If now the essential constituent for which madder is so valuable, its pure colouring matter, can be economically prepared by chemical means from coal-tar, that amount of money will naturally go into our own pockets—a not unworthy reward for chemical ingenuity.

The value of madder in dyeing and calico printing depends upon the many different colours which can be dyed by its means; thus, one mordant (iron) gives purple shades, from the most delicate mauve to black; with another mordant (alumina), red shades are produced, from the palest pink to deep crimson, including the brilliant and well-known Turkey red; and by judicious admixture of these mordants, combinations of all varieties of chocolate-brown are produced. These colours are very permanent, whilst the high price of the raw material to which they are due renders the discovery of a substitute a problem of the highest commercial importance. For these reasons the chemical investigations of madder have been very numerous, the most valuable results having been obtained by our own countryman, Dr. Schunck. This chemist found that the root did not contain a colouring matter ready formed, but there was in it, amongst many other bodies, a crystalline substance, which he named *rubianic acid*. When the powdered madder is allowed to stand in a moist state, or is gently heated with water in the dye-beck, a peculiar fermentation sets up under the influence of a ferment called erythrozyn, by which the rubianic acid is split up into alizarine and glucose. Besides alizarine, there is another colouring matter obtained from madder, called purpurine; but as all the valuable shades and colours of madder are due to the alizarine, we need only devote attention to the latter substance.

Alizarine is a brilliant scarlet substance, which crystallizes in

prisms, and when exposed to carefully-regulated heat, sublimes, condensing into beautiful tufts of scarlet needles; it is only sparingly soluble in water, but dissolves in spirit, and in alkaline solutions; its tinctorial power is at least thirty-five times as great as that of madder itself. Dr. Schunck was the first to point out that Turkey red, madder pink, and all the finer madder colours, are simply compounds of alizarine and fatty acids with bases, and he has described a process for preparing pure alizarine from cotton which has been dyed Turkey red.

The discovery of the method of preparing alizarine artificially is due to two continental chemists, Messrs. Graebe and Liebermann, and their discovery is the more remarkable, since it has not been effected by any haphazard, rule-of-thumb system of experimentation, but is the result of a scientific investigation on the properties and molecular structure of alizarine, and has been conducted, step by step, in accordance with logical deductions from the known laws of synthetical chemistry. The train of reasoning is too complicated, and requires too profound a knowledge of the laws of modern chemistry, to be given in detail here, but a brief outline of their research will perhaps be of interest.

From an examination of the substances obtained when pure alizarine from madder was submitted to sundry chemical processes, it was ascertained that this principle was connected with the hydrocarbon group containing fourteen atoms of carbon, and by heating it with a body capable of removing oxygen, they obtained from it the hydro-carbon of the group, containing fourteen atoms of carbon and ten of hydrogen. This was seen to be identical with one of the solid crystalline bodies obtained in the distillation of coal, named anthracene; and by a somewhat complicated process they converted this into anthraquinone, then into bibrom-anthraquinone, and lastly, into alizarine; having by this means added four atoms of oxygen to and removed two atoms of hydrogen from the alizarine. The key to the synthetical formation of alizarine having thus been discovered, it was not long before improvements were effected; for when a particular series of chemical reactions have to be performed, a clever chemist can always find different ways of effecting them, as the records of many a celebrated patent case will show. There are now four processes in operation, three of which are patented, whilst one is being worked secretly. All effect the same purpose by somewhat similar means, but by the use of different reagents, and all start from anthracene. Mr. Perkin's patent is now in operation in this country, and his artificial alizarine is in use amongst the Scotch dyers, where it is competing favourably with madder. Besides alizarine, other colouring matters are formed during these synthetical operations; and unless care is taken in the purification, the tones produced by the artificial colouring matter are liable to be somewhat yellowish;

but when pure, there is no doubt as to the identity of the artificial and natural dyes, as they are similar in their absorption spectra, their tinctorial powers, their unalterability under the influence of light, and their solubility.

Whether artificial alizarine will supersede madder to any great extent depends principally on the supply of the raw material, anthracene. Dr. Roscoe says that in an experiment made on a large scale it was found that 100 tons of tar yielded 0·63 ton of anthracene, or 1 ton of anthracene could be obtained from the distillation of about 2000 tons of coal, not reckoning the quantity of anthracene contained in the pitch. But tar distillers have hitherto turned very little attention to this substance, and from some experiments of Mr. Perkin it is probable that some kinds of coal-tar contain considerable quantities of anthracene. Attention being now directed to the subject, all experience tells us that the demand will bring a supply, and already we see signs of this in the advertisement pages of chemical periodicals, where the price of anthracene is regularly quoted along with that of other coal-tar products. Should our anticipations be fulfilled, this discovery, although made by German chemists, cannot fail to be of most benefit to England, the great tar-producing country of the world. Tar distillers will do well to bear this in mind, and examine the influence of various temperatures in distillation, for anthracene is likely to become as important as benzol was a few years ago.

W. C.

NOTICES OF SCIENTIFIC WORKS.

FORMS OF ANIMAL LIFE.*

TWENTY years ago a number of statutes were passed in the University of Oxford indicative of a commencing change in the educational methods pursued at that venerable institution, of which change the book before us is one of the fruits. The "progressive studies," and prominently among them the study of the natural sciences, were introduced as legitimate objects of pursuit; and the admission thus made that, in the opinion of some, they were at least competent to supplement, if not to supplant, as agents of intellectual discipline, the investigation of the ancient classics, or of the philosophical works of Kant and Hamilton.

Whether science, however, as distinct from literature, be efficient in developing the mental faculties and engendering correct habits of thought, must depend entirely on the method in which it is pursued. It must be obvious to anyone who has had much experience in teaching, that it is quite as easy—and perhaps even easier—for a youth to acquire a scientific as a classical pedantry; to be able glibly to talk chemistry, as many boys do their Latin, by employing a confused jumble of words and formulæ, without the slightest appreciation of broad general principles. It is, indeed, quite marvellous how little has been effected in England in some branches of science, even under circumstances that would at first sight appear most favourable, merely through the pursuit of a wrong method. Ask ninety-nine out of a hundred senior medical students what the effect of a section of the phrenic or the sympathetic nerve would be, and they will probably detail certain characteristic changes in the respiration and circulation. Supplement the first question by another requiring the source of their information, and they will at once give the name of the compiler of the physiological text-book most in vogue at the time. Now ask two similar questions concerning the situations of these nerves in the human body, and the replies will be of a very different character. Their directions and relations to contiguous parts will be promply set forth; and in reply to the second query the students will inform you that they have seen the nerves with their own eyes, and dissected them with their own scalpels, and are quite prepared to prove the correctness of their statements by a demonstration of

* 'Forms of Animal Life: being Outlines of Zoological Classification based upon Anatomical Investigation, and Illustrated by Descriptions of Specimens and of Figures.' By George Rolleston, D.M., F.R.S., Linacre Professor of Anatomy and Physiology in the University of Oxford. Oxford: Clarendon Press.

them in the anatomical theatre. In the first case the knowledge is hearsay, in the second it is the result of close individual observation, and is therefore real.

Now it is the acquisition of a real and substantial basis of facts —facts which must be verified again and again by the observing eye and sensitive touch—to which physical and biological science, as an engine of education, should first prompt the student. In other studies words come to him invested with the authority conferred by the name of some master. In these he is to believe what he sees and can prove by experiment.

If it be asked why two such nearly related subjects as Anatomy and Physiology should be studied so differently, and with such different results, we think the answer is near at hand. Comparative anatomy, as a branch of scientific education, has, until recently, been almost entirely neglected, and even now is not extensively taught. Comparative physiology cannot be studied without a preliminary groundwork of comparative anatomy. While, thirdly, almost all advance in human physiology must depend on experiments made on the lower animals. In these three statements we have indicated what we conceive to be the true answer. Students cannot themselves work out the physiological problems connected with the nerves in question, or any other similar part, because they are not sufficiently familiar with their relative position in the only bodies on which experiment is possible, *viz.* those of the lower animals. When a course of comparative anatomy, carried out not merely by dry lectures, but by actual dissections and demonstrations on familiar representative animals, be considered an integral part of a medical education, and not till then, will physiology be generally studied according to a better method.

But if an English student of medicine of to-day desires to fit himself for pursuing physiological studies after the manner indicated, or by practical dissection to enlarge his knowledge of those empirical laws which underlie animal forms, whither is he to look for a guide —such a guide as books on anthropotomy afford him in his practical study of the human body? Except the book before us, we do not know any that would serve his purpose. There are many books of great value which give the results of comparative anatomy; as, for example, Professor Owen's great work; or the remarkably lucid and able 'Introduction to the Classification of Animals,' by Professor Huxley. But their scope and aim are different. Professor Rolleston's book does then, we think, supply a real want.

By the aid of its very clear descriptions, and, if possible, still clearer figures, the student is enabled to dissect and recognize all the salient points in the anatomy of a rat, pigeon, frog, and many another familiar and typical animal. The volume is not intended for the mere reader of comparative anatomy, and will do him no good—

or at least no more good than any other able treatise on the subject. It is designed as an aid to the practical worker; not to burden his memory and confirm him in the enervating habit of receiving on trust statements which ought to be verified by observation, but to educate him into the way of educating himself. Though written primarily for the benefit of students of the University of Oxford, in the museum of which institution an illustrative series of preparations exists, we think we have said enough already to prove that its advantages need by no means be limited to them; but that it will prove most useful to all those who desire, like we did in our own student days, a reliable guide by which to work. To go through the book as the author designs it to be gone through, and as the reader for his own sake should make up his mind to go through it, will involve both time and labour; but they will be time and labour well expended.

There are three parts to the work. First, an introduction, "giving a classification of the animal kingdom, with a zootomical account of the various sub-kingdoms and their subordinate divisions and classes." Secondly, a "description of certain readily procurable specimens, which illustrate in the concrete a very large number of the systematic descriptions contained in the introduction;" and thirdly, descriptions of figures supplementary to the descriptions of specimens, and designed to aid those specimens in "furnishing that groundwork of particular facts, without which it is impossible to obtain any real knowledge or permanent hold of general principles." This endeavour to erect the principles of the science on a firm basis of fact, which the student is taught how to observe for himself, is the unique and most valuable feature of the book.

Of the three parts, the first consists of 168 pages, and is recommended in the preface to be studied after the preparations and specimens whose descriptions succeed it. We do not quite see, as these are to be read first (as they undoubtedly should be, and that too as a commentary on actual specimens; all the better if actually made by the reader), why they should be placed second. This is a matter of small moment perhaps, except that a book is generally written in the order in which it is intended to be read; and that a good many people either pass over prefaces altogether, or read them just as authors write them, namely, after they have finished the works to which they are intended to be the real introductions. One of the most striking features of this first part is its extreme truthfulness. No attempt is made to construct a completer system than Nature herself has given. Everything in it is reliable, because in everything Nature has been followed, not led. Nothing is easier than to fix on some one character as a basis, on which a zoological system can be constructed, whose symmetry and philosophic completeness shall captivate the mere reader of zoology—nothing, except the readiness

with which this symmetry can be shown to be unreal. We could point to more than one book, whose numerous editions testify to their numerous readers, written on this principle. In the "Introduction" before us, if we miss a little of the charm of a completeness, easily attained when men construct animal kingdoms out of their own imaginings, we recognize in every page the far more substantial advantage of a severely conscientious truthfulness. Scarcely a fact of broad and general application is stated, that has not the "but," which introduces all the exceptions to it, immediately after; and it will be a great satisfaction to the student of the book to know that, however much he may have to supplement the knowledge it affords him as the science of comparative anatomy may advance, he will have little or nothing to unlearn.

The admirable calmness and temper displayed when the passing discussion of any biological theory is rendered necessary; the carefulness with which conclusions which are merely probable are distinguished from others that bear the stamp of certainty; the evenness with which the balance is held between opposing probabilities—as for example at pp. xxv. and clxii. respectively, where the theories of evolution and of the existence of a *regnum protisticum* are reviewed; and the readiness everywhere manifested to accept any new truth when proved, coupled with a cautiousness in disparaging the old simply because it is so, cannot fail to exercise a wholesome influence on the mind of the reader.

In two ways we venture to think the value of this part might be enhanced. First, by the addition to it of some such glossary as that appended by Dr. Pye Smith to Professor Huxley's "Introduction." Secondly, by the devotion of a single figure and about a page of description to the elucidation of the constituent parts of a complete vertebra; in the absence of which the student is referred, at p. 9, Part II., to Professor Owen's 'Descriptive Catalogue,' a work not easily obtained, except by those living in Metropolitan or University towns.

The second part consists of the descriptions of fifty preparations obtained from representative, and for the most part easily procurable animals, such as the rat, pigeon, common fowl, frog, perch, crayfish, &c. While they are so clear as to enable the student easily to recognize in the preparation before him its anatomical details, or to make the preparation for himself if he has not access to a museum containing it, they are something more than mere descriptive sketches of the particular animals under consideration. Each serves as a text for a discourse on the entire class, and side by side with the account of every organ are allusions to homologous organs of creatures in allied orders. With the descriptive anatomy of the common crayfish, for example, are frequent comparisons of its different parts with those of other Decapods, both brachyurous and macrourous; of Iso-

pods, Amphiopods, and many others; so that by being thus grouped around one central and familiar figure, the resemblances and differences can be better appreciated and more easily remembered.

In the third part are twelve plates containing drawings of nine dissections of common animals, executed from the dissections themselves, by Mr. G. Crozier, formerly draughtsman to the Radcliffe Library, Oxford; and sixteen diagrams taken from the best sources. In the descriptions, which serve as comments on these figures, there is necessarily at times some amount of repetition of what has been gone over in the previous part. Nobody, however, who knows how much the impressions of facts upon the mind are deepened by their being presented in different manners, will regret this. The facts of anatomy, as every teacher or learner of it knows, have to be reiterated many times before they become retained.

A certain amount of preliminary knowledge is necessary before this book, or indeed before any book on comparative anatomy, can be beneficially studied. It is not much. One session's steady work will give any average student a fair knowledge of human osteology and visceral anatomy, and then he will be prepared to enter with advantage on such a study of comparative anatomy as Professor Rolleston has here so admirably sketched out for him.

OTHER WORLDS THAN OURS.*

THE first sentiment of a thoughtful man untrammelled by the influences of doctrinal theology, when he hears the question, "Are the celestial spheres intended as the abode of life?" is one of profound astonishment. The more natural inquiry, it seems to him, would be, "Why should the other worlds not be the seats of living organisms?" and the very question reminds him at once of the littleness of his race, and of the restricted mental capacity which can seriously entertain such a doubt. Imagine a colony of ants, who have raised, what appears to them, a vast monument of their enterprise and industry in the shape of a little mound, upon some islet in a vast lake; and conceive of the complacency with which the ant-philosophers will gaze upon the neighbouring islets, from which they are separated by an impassable barrier, and of their grave deliberations as to whether those other vast regions are peopled with beings like themselves, or what can have been the object Nature had in view when she raised up other lands besides their own? This is precisely the position of our philosophers who cling to the idea that

* 'Other Worlds than Ours: the Plurality of Worlds studied under the Light of Recent Scientific Researches.' By Richard A. Proctor, B.A., F.R.A.S. Longmans, Green, & Co.

ours is the only habitable world, and that the rest are but shining lights placed in the heavens to give us light by night.

If we thought that many of our readers continued to hold this doctrine, we should indeed lay down our pen in despair, and descend to themes which come within the scope of the utilitarian understanding; but thanks to the rapidly advancing strides of science, we may fairly assume that a large proportion of the readers who consult these pages are quite prepared to consider with the author of the work before us, not whether other worlds are the seats of organized existence, but whether we have any, and, if any, what kind of evidence concerning the nature of the living forms which now inhabit, or are destined in future to reside upon, the other celestial spheres.

In considering the question from this point of view, we are compelled still to admit our profound ignorance; but we may do so without shame or humiliation, for in this case it is no longer the unreasoning ignorance of the lower animals—we are no longer ant-philosophers—it is the darkness which precedes light; the gloom that is being dispelled, slowly but surely, by the efforts of philosophical research, through that quality of the human mind which distinguishes us from inferior intelligences. We know very little indeed of the conditions of existence in spheres other than our own, and although Mr. Proctor has managed to write a book of more than 300 pages on the subject (a great portion of which, however, deals with matters interesting enough in themselves, but completely alien to the main inquiry), all that has been ascertained with anything approaching to certainty as bearing upon the habitability of the heavenly bodies, might easily be compressed into a dozen sentences. So that if we were strictly to obey the injunction which is given to young lawyers, that before they begin to consider the law in any particular case upon which they are consulted, they should thoroughly master the facts; if, we say, we were to apply this safe method to the question, what kind of beings are living or destined to live upon the heavenly spheres, the consideration of the subject might be long deferred, and we should have to pronounce upon it with great doubt and hesitancy.

Around Mercury there is probably some kind of atmosphere, but the planet is too near the sun to admit of a satisfactory examination with our present philosophical instruments. Venus almost certainly possesses an atmosphere, and the inclination of her axis leads us to infer the existence of seasons.

Mars is the great *pièce de résistance* in this light intellectual banquet. That planet has almost certainly an atmosphere heavily laden with clouds, two poles similar to our own, capped with snow which encroaches upon and recedes from its more temperate zones according to the seasons of the Martial year of 687 days; those seasons being, like our own, the consequence of an inclination in

the axis of the planet to its orbit. But our information concerning Mars does not stop here, for astronomers are sufficiently convinced of the existence on its surface, of continents, islands, oceans, seas, straits, and inlets, to have given them such designations as W. Herschel Continent; Kepler, Lockyer, &c., Lands; Phillips Island; Dawes Ocean; De la Rue Sea; J. Herschel Strait; Nasmyth Inlet, &c., as may be seen from Mr. Proctor's interesting chart in the work under review; and if these surmises be correct—if the fair face of Mars is divided into land and water, and if its skies are varied with clouds and sunshine, it is only a reasonable inference that in every other respect its physical aspect resembles that of our own earth; its continents being diversified by hill and dale, plain and valley; its valleys adorned with lakes, and serving as the beds of rivers; whilst waterfalls will likely adorn its hill sides, and glaciers its mountain recesses. And if so, *cui bono?* Are there no trees and shrubs to draw their nourishment from its streams and watercourses? no insects nor other flying things to flutter in its sunshine? no living, moving beings to wander over its vast continents? And if some of these should still be absent, has all this beauty been produced in vain *for ever?* We leave the common sense of our readers to dictate the answer, for they are as well able to form an opinion on the matter as the author of the work before us.

From the slight inclination of its axis, Jupiter has no seasons in the ordinary acceptation of the term, but probably the planet possesses a cloud-laden vapour with its consequences. It is possible that Jupiter may be in a condition somewhat similar to that in which our earth was when its seas swarmed with ancient forms of life. Mr. Proctor does not say so, but judging from the necessity of a supporting medium for its animal races (if it possess any), in consequence of their additional weight as compared with those on the earth's surface, as will be explained presently, and from other circumstances, such a view is worth consideration. Saturn, too, has probably an atmosphere laden with vapours; and here our knowledge, which can hardly be called positive, of the phenomena favouring the existence of life in other parts of our Solar system, terminates.

There are, on the other hand, certain well-established phenomena which render life impossible upon certain other spheres. The photosphere of the Sun consists probably of glowing vapours, amongst which those of many well-known elements, such as iron, calcium, magnesium, as well as hydrogen gas, have been distinctly traced by spectrum analysis; and so, too, similar elements in the same form, sodium, magnesium, iron, hydrogen, have been clearly ascertained to exist in some of the fixed stars.* In such an atmosphere, it is

* See Huggins "On Recent Spectroscopic Researches," 'Quarterly Journal of Science,' April, 1869.

safe to say that no beings at all resembling those which live on earth could possibly exist. Again, that side of the moon which is visible to us has, in all probability, neither atmosphere nor water, and it is subjected to the unimpeded action of the sun's rays for the space of fourteen days without intermission, a protracted tropical day, which is followed by an Arctic night of equal duration. Although there are grounds for believing that in past æons our satellite may have been the abode of life, it is hardly possible, for the reasons named, that it can be so in our time.

Again, there are circumstances from which it may reasonably be inferred that even where it is legitimate to assume the existence of living creatures on certain orbs, they must be constituted differently from those we know on our globe. For example, an object which on the earth's surface weighs 1 lb., weighs only 7 oz. on Mercury, but the same object would weigh $2\frac{1}{2}$ lbs. on Jupiter; so that a man of 10 stone here would have to carry 25 stone on Jupiter, and only 4 st. 6 lbs. on Mercury; and Mr. Proctor, if he had wished to indulge his lively imagination more freely than he has done, might have conceived of Mercury as an advanced planet, peopled by a superior race of beings, who having a lighter weight to carry and consequently less need for muscular exertion, would probably require only one meal a day to compensate for physical waste, and would therefore have more time and energy to devote to higher occupations than mere nutrition. And, as already mentioned, the additional weight which creatures would have to carry on Jupiter, with its present size and density, suggests the idea of its containing vast seas, that support Ichthyosaurs and their congeners. These are, of course, speculations, like Mr. Proctor's; but it may be as well to mention that on all matters involving biological as well as physical considerations, even speculators should be conversant with the past history of life on our earth; should be geologists and palæontologists as well as physical and astronomical observers. The more we study Nature as a whole, the greater the need appears for a school of thought which shall embrace all natural sciences.

In regard to the condition and habitability of other spheres, one consideration—for it is absurd in the present state of our knowledge to talk of conclusions—seems to press itself upon us, namely, whether smaller orbs, as the nearer planets (Mercury, Venus, the Earth, Mars), and the satellites in the Solar system, do not mean advanced life, or (as on our Moon) life already passed away; and the larger planets, and the Sun itself, retarded inorganic and organic existence.

Those who desire to be fully informed as to Mr. Proctor's views on these matters must turn to his interesting pages; but it may be remarked here, that he believes the exterior planets to be what may be called semi-solar in their character, not only receiving heat from

the Sun, but, from their peculiar condition, having the power to impart more than they receive, and so serving as suns to their systems of satellites which he regards as true worlds. Why under these circumstances he talks of Uranus and Neptune, which he includes in his subsidiary Solar system,—indeed he speaks of Jupiter, Saturn, Uranus, and Neptune as "four suns" *—as Arctic planets it is difficult to understand.

Having dealt with what may be termed the legitimate portion of his subject—the habitability of the spheres—in the first half of his book, the author proceeds to consider such objects and phenomena as meteors and comets, the other suns, nebulæ, and he concludes his volume with a chapter on "Supervision and Controul."

We have space only for two or three passing criticisms. Mr. Proctor adopts and enlarges upon the meteoric theory of the universe, which differs from the nebular theory of Laplace, in assuming that at some time or other there was a chaos of moving meteors and that these agglomerated into masses. In our Solar system, for example, the sun first drained space of an immense quantity of meteoric matter, leaving but little in its own immediate neighbourhood, so that first smaller planets were formed; but as the attractive force of the central orb diminished, larger centres (Jupiter, Saturn, &c.) were again set up; whilst in other portions of the universe similar processes were going on. This hypothesis has received, and will continue to receive, much attention. It is a kind of Darwinian theory of the universe, not attempting to go back to the beginning (for it is as difficult to account for the formation of a *meteor* as of a *sun*), but endeavouring to reason by strict logical induction from known and present phenomena to the probable past. Whoever reads Mr. Proctor's argument, however, will be struck by his straining to appropriate all known phenomena, even such as offer contradictory evidence, in his own favour; whereas, many of his facts or supposed facts are quite as applicable to the views of Laplace as to the Meteoric hypothesis; and such phenomena as the gaseous nebulæ, their proximity to star systems, and their probable absorption by such systems, tell at least as strongly against, as for, the theory which he has adopted. Here, too, in his great flights of fancy the author fails to see the full significance of some of the phenomena to which he refers. Astronomers are in the habit of saying that we see creative processes *now* going on in the heavens; meaning thereby that we see nebulous matter being formed into worlds *to-day*. In all probability this is only true in one sense. The author, quoting an anonymous writer, shows that we see many of the distant stars, not as they are to-day, but as they were in ages past, for their distance from us is so enormous, that the light which brings us

* P. 174.

intelligence of their condition has been ages in speeding through space. The application of this fact to the appearance of nebulæ and what may be considered as worlds in course of formation, is not dwelt upon sufficiently; for just as we see the formed suns as they existed in past æons, so do we *now* observe the condition of nebulous masses as they *formerly* existed. Here, again, a little palæontology and archæology would have done the author no harm. Just as the Almighty has left us fossils in our terrestrial strata, flints in our burial mounds, and inscriptions upon our tombs to instruct us in the past history of the earth and its inhabitants, so He unfolds to us—not as with His all-seeing and omniscient faculties, but through the very imperfection of our senses, through our inability to leave the surface of our little earth, and the consequent necessity that we should stay here and await the intelligence of the past,—so, we say, he shows us the whole history of the universe at one glance, revealing to us to-day stages of formation and progress which existed at periods long past, in a ratio of time measurable by the space through which the message-bearing ray has had to pass in its mission of knowledge. In other words, as soon as our instruments enable us to measure the distance from us of a fixed star or nebula, and show us its condition, we are able to compute at what period of the past, reckoning backwards from to-day, the object we are viewing was actually in that condition, and we have therefore a more precise method of ascertaining the time which has been requisite to bring about cosmical changes than we at present possess for determining the periods required for the deposition of terrestrial strata.

As to Mr. Proctor's views on "Supervision and Controul," they are as suggestive as all his other chapters, but they are not likely to gain much favour, from the author's timidity in expressing his views on controverted subjects. It is not difficult to guess what these are; but when a writer says he will give us an insight into the nature and operations of the Almighty, but he sees no advantage in making people uncomfortable by saying what he himself thinks on just those matters on which he is best able to form a judgment, his views of Divine action are not likely to be much heeded either by "believers" or "unbelievers." The book has other faults. It is of too mixed a character, treating in some places (as where the principles of the spectroscope are explained) of physical phenomena in terms suited for a schoolboy, and in others discussing controverted points in astronomy with the earnestness and particularity of an experienced disputant, and not always without the suspicion of some little unphilosophical animus.

No one will accuse us, after these criticisms, of having followed the too common but ignoble practice of handling tenderly, if not of flattering, the productions of a collaborateur, but we are bound to

say in conclusion, that we have been much charmed by the perusal of the work. It is in many places very poetical; its author shows himself to be a careful and earnest observer, and the novel aspects in which old phenomena are presented to the reader are deeply interesting and often startling. The beautiful chromo-lithographs are amongst the best we have seen, and they convey vivid impressions of the heavenly bodies which they are intended to represent.

COMPARATIVE LONGEVITY.*

MR. LANKESTER has published an Oxford prize essay on Longevity, and his little book merits the attention of a wider circle of readers than it would be likely to find within the precincts of the University. The title was, of course, not of the author's choosing, and as originally given out was as follows:—'The Comparative Longevity of different Species of Lower Animals, and the Longevity of Man in different States of Civilization.' As the author very properly says in his preface, "The subject does not admit of very satisfactory treatment from a scientific point of view, and is accordingly one which probably few persons would have selected to write upon, unless under special circumstances," "but at the same time," he remarks, "longevity is a subject of great popularity, and hence the facts and arguments herein set forth may, it is hoped, interest the public."

Although we should not feel justified in complimenting the author upon his treatment of the question from any other than a scientific point of view, and are unable to accredit him with success in having imparted greater popularity to this subject, we have no doubt that the essay will materially add to his rapidly increasing reputation as an accurate observer and promising naturalist, for every page bears evidence of careful thought and extensive reading.

In conformity with the apparent wishes of the examiners or judges, he has divided his subject into two sections, the first of which treats of longevity in organisms generally, and the second of longevity in man.

His definition of longevity would be apt to puzzle non-scientific readers, for it is "the length of time during which life is exhibited in an individual;" but the meaning intended to be expressed, as subsequently explained, is that it is the "potential duration of life" in an "individual," as distinguished from a group or succession of individuals, as in the case of asexually-produced polyps, for ex-

* 'On Comparative Longevity in Man and the Lower Animals.' By E. Ray Lankester, B.A., Oxon. Macmillan & Co.

ample. A reference to the author's carefully and conscientiously prepared "Statements as to the duration of the individual in organisms" (pp. 55 *et seq.*), shows upon what slender data he has been compelled to base his conclusions; for concerning whole groups, hardly anything appears to be known in this respect, and even where our knowledge is less scanty, line after line is preceded by the author's notes of interrogation.

His conclusions regarding the duration of life in the lower animals are as follows:—

"Hence, in spite of the great complication of the case, we may conclude, on both deductive and inductive grounds, that the high or low potential longevity of different species, as a general law, is necessitated by those conditions of life which necessitate high or low individual development, as the case may be, whether of bulk, or complexity, or both, that it is directly subject to those conditions which cause personal expenditure to fluctuate, or which affect generative expenditure, being high when these are low, and low when these are high; that these relations, interacting and contending variously according to the special case, determine the potential longevity of the various species of lower animals.

"From the intricacy of these relations we may conclude that potential longevity is a very delicately balanced quantity, and that very *slight* causes may produce great fluctuations in it and be almost impossible to trace; the magnitude of the result being far larger in proportion to the magnitude of the initial cause, as is so often found to happen in biological science" (pp. 87–88). It may be as well to add, by way of explanation, that the author means by personal expenditure, "that involved in the wear and tear of assimilating food, and generally carrying on life" (p. 48).

When he comes to treat of longevity in man, his essay, as might be expected, is more popularly interesting, and its interest is enhanced by the originality of some of his observations. He attributes a longer life to man in civilization than in a state of nature. "Civilized man," he says, "lives in societies, one of the most essential bonds of union in which is the maintenance to a greater or less extent by the community of the feeble. The security which the healthy and vigorous man hopes for himself when grown old and feeble he naturally extends to others, and thus the aged are fed and protected as the result of a specific habit or characteristic among men (the most barbarous excepted)" (p. 88). This is the scientific re-statement of the commandment, "Honour thy father and thy mother, that thy days may be long upon the land which the Lord thy God giveth thee."

The author's account of the rise and spread of our race, and his partial application of Mr. Darwin's theory, only disappoint us by their brevity, and his conclusion is incontrovertible that "individual

men do not struggle for existence—that is assured to them by society—they struggle "to get on." This is practical Darwinism, and the author shows that the expenditure of brain-power in man's case affects the potential duration of his life. He reviews carefully the phenomena bearing on this aspect of the question on savage and civilized life, and his conclusion is, "that a civilization of the highest order in which the efficiency of the community and the efficiency of the component individuals is greatest—in which there is the most harmonious action, the greatest happiness for the greatest number, the least excessive expenditure with the least luxury, where regularity and temperateness are innate characteristics, will be that state of civilization most favourable to longevity."

But there is a set-off against this: great thinkers do not live so long as those who take things more easily, and we find from his tables that *less* distinguished men in every profession enjoy longer lives (in one sense of the word "enjoy") than those who are more distinguished. If the millennium were reached, "men would no longer die of disappointment, but would all attain 80 or 100 years. There is no apparent reason why longevity should not increase beyond that limit, and advance with advanced evolution, and the diminished expenditure implied in complete adjustment" (p. 128). There is, however, another matter to be considered: Will not the limited area of our globe be pretty well covered with human denizens before that happy day dawns upon us? and what then? However, that is a matter for posterity to consider; and meanwhile we cordially recommend Mr. Lankester's suggestive little volume to our biological readers.

CHRONICLES OF SCIENCE,

Including the Proceedings of Learned Societies at Home and Abroad; and Notices of Recent Scientific Literature.

1. AGRICULTURE.

THE extreme drought of the past three months is by far the most important of recent agricultural events to put upon our record. Already, in early June, throughout the southern counties, pastures are becoming bare and brown, and spring-sown crops are dwindling. Clover and other forage crops are not yielding half their usual produce to the scythe; wheat alone has not yet materially suffered, but a continuance of dry weather must injure the wheat harvest too. Wheat, indeed, "needs no rain after May;" but that is only when May itself has soaked the ground. The usefulness of artificial manures depends very much on the wetness of the growing season. No applications in the way of top-dressings to growing crops are made when they would obviously be useless; and this great aid and stimulant to fertility being lost, the year's produce thus suffers indirectly also from the drought. The Cirencester Chamber of Agriculture has reported the favourable results of top-dressings of nitrate of soda and superphosphate of lime on the wheat and barley crops of the Cotswold soils. On three experimental plots, the average increase of grain per acre per 100 lbs. of the former dressing by itself was 276 lbs. The average increase per acre of four plots per 100 lbs. of the former together with 200 lbs. of the latter dressing was 517 lbs. of grain. In other cases the difference due to the added superphosphate was not so great; but the conclusion, upon the whole, seems to have been that nitrate of soda, applied as a spring top-dressing to wheat, whether by itself or not, yields a satisfactory increase of produce; though the result of the combined dressing of superphosphate together with the nitrate was still more satisfactory. The practice of top-dressing grain crops in spring is a growing one; and as no one thinks of making this application, except in wet weather, this is an advantage which this year's harvest will have lost.

Dr. Voelcker continues to report to the Royal Agricultural Society of England the results of his constant analyses of commercial manures and cattle foods—showing to how much fraud and roguery English agriculturists are exposed. Guano is this year unusually various in its composition—even genuine Peruvian guano is sometimes damaged by sea-water, or contains an excessive quantity of sand. Samples are reported containing as much as 17 per cent. of water and 5 to 9 per cent. of useless mineral matter, and only 12 to 13 per cent. of ammonia—being thus worth less by 30*s*. or 40*s*. a ton than the price at which Peruvian guano is now sold.

Another artificial guano, containing 26 per cent. of water and 60 per cent. of lime and sand, &c., and not 1 per cent. of ammonia, is sold at 70*s*., while it is not worth carrying a mile if it could be had for nothing. Other manures still occasionally find purchasers, though absolutely worthless, or even mischievous. Oil-cakes of various kinds, as well as fertilizers, pass through Dr. Voelcker's hands, and faulty samples, under analysis, lose the character under which they have been bought and sold: and the publication by the Royal Agricultural Society of these investigations by their chemist must ultimately prove serviceable.

A very instructive discussion by Mr. Lawes on the waste of food during respiration has been published with a view to the elucidation of sound farm practice in the meat manufacture. It is obvious, as he points out, that in the case of animals fed for the butcher the economy of the feeding process will be the greater, the less the amount of food expended by respiration in the production of a given amount of increase; and it is equally obvious that one ready and efficient means of lessening the proportion of the waste or expenditure to the increase produced, is to lessen as far as possible the time taken to produce it; in other words, to fatten as quickly as possible. From numerous experiments made at Rothamsted it appears that a pig weighing 100 lbs. will, if supplied with as much barley-meal as he will eat, consume 500 lbs. of it, and double his weight—that is, increase from 100 lbs. to 200 lbs. live weight—in seventeen weeks. Of the 420 lbs. of dry substance which the 500 lbs. of barley-meal contain, about seventy-four are stored up in the 100 lbs. of increase in live weight, about seventy are recovered in the manure, and 276, or nearly two-thirds of the whole, are given off into the atmosphere by respiration and perspiration—that is to say, are expended in the mere sustenance of the living meat-making machine, during the seventeen weeks required to produce the 100 lbs. of increase.

Mr. Lawes points out that if instead of allowing the pig to have as much barley-meal as he will eat, the 500 lbs. of meal had been made to last many more weeks, the result would have been that the animal would have appropriated a correspondingly larger proportion of the food for the purposes of respiration and perspiration, and a correspondingly less proportion in the production of increase. In other words, if the 500 lbs. of barley-meal were distributed over a longer period of time, it would give less increase in live weight, and a larger proportion of it would be employed in the mere maintenance of the life of the animal. Indeed, if the period of consumption of the 500 lbs. of meal be sufficiently extended, the result will be that no increase whatever will be produced, and that the whole of the food, excepting the portion obtained as manure, will be expended in the mere maintenance of the life of the animal.

The conclusion is obvious, that, provided the fattening animal can assimilate the food, a given amount of increase will be obtained with a smaller expenditure of constituents by respiration, the shorter the time taken to produce it. In fact, by early maturity, and the rapid fattening of stock, a vast saving of food is effected.

Mr. Lawes has lately made a practical use of the conclusions to which his Rothamsted researches have led him in connection with another branch of farm practice. In a paper read before the London Farmers' Club on the exhaustion of the soil in relation to landlords' covenants and the valuation of unexhausted improvements in favour of an outgoing tenant, he drew a distinction between the natural fertility of a soil, which is the property of the landowner, and the "condition" of the soil, which is often properly the property of a tenant. The following are the practical results which he considers follow upon his discussion of this subject:—

"Condition" is a quality distinct from natural fertility of soil, and is mainly dependent on the amount of capital expended by the tenant in the purchase of cattle food or manures. It is, therefore, his property, and may be easily and rapidly reduced. —The natural fertility of a soil, on the other hand, whether high or low in degree, is, comparatively speaking, a permanent quality; it can only be injuriously affected by the continuance of an exhaustive system of cropping for a long period of time; it is the property of the landlord; and, excepting in the case of very light soils, it is the chief element in determining the rent-value of the land.—No injury is likely to result to the landlord in the case of the heavier soils from granting the tenant permission to crop as he pleases, provided he be bound to keep the land free from weeds, and to leave a fixed proportion under fallow and green crops at the termination of his occupation.—By the valuation of so much of the farmyard manure, and of so much of the manure constituents derived from purchased cattle food, as have not yet yielded a crop, and also of the straw of the last harvest, fair compensation may be made to the outgoing tenant.—If abundant capital is to be attracted to the soil, it is essential that liberal covenants in regard to cropping should be adopted, and fair compensation for unexhausted improvements made.

Among the remaining principal events which have lately happened in the agricultural world must be named the remarkable favour with which the so-called A B C process for dealing with the town sewage nuisance has been received by many towns on which the adoption of it has been urged. Chemical analysis does not endorse the extravagant assertions which have been made regarding the merits of the process. The water is still foul after sewage has been acted on by the A B C mixture; and the dried mud which it throws down, for which 70s. a ton is the price demanded, is not worth, even

theoretically, one half that sum; while, practically, it must be pronounced of very little value indeed. The valuation of 1 or 2 per cent. of "combined nitrogen" in the midst of a mass of clay and other inert mineral matters cannot be conducted on the same scale as is applicable to the ammonia of a manure in which it forms $\frac{1}{6}$ or $\frac{1}{7}$ of the total weight. And in addition to the lower theoretical value of "combined nitrogen" in this diluted form, it is practically so much the less valuable on account of being loaded with a lot of worthless stuff, the expense of applying which to the land has to be deducted from any result of the application which may be due to the small quantity of fertilizing matters with which it may be charged. Nothing connected with this or any other scheme for sewage utilization has at all shaken the conclusion, to which the Rivers Pollution Commissioners had been led by their investigations, that sewage irrigation is not only the best method of sewage defæcation, but the only known plan by which its filth may be profitably converted into fertility.

2. ARCHÆOLOGY (Pre-Historic).

'Flint Chips' is the title of a book just issued by the Trustees of the Blackmore Museum, Salisbury, written and compiled by Mr. Edward T. Stevens,* their honorary curator. Few private gentlemen have merited the thanks of men of science more justly than Mr. William Blackmore, by whose munificence the town of Salisbury has been enriched with the excellent Museum of Prehistoric Archæology described in the clearly-written and well-printed pages of the book before us.

Mr. Stevens's work has been written with a view to illustrate the Stone age by the help of the collections in the Blackmore Museum; but he has really done far more than this, for we learn from these pages the history of "Wampum"—that very useful article in whatever part of the world we may be cast—of the earliest known evidence of the use of tobacco as evidenced by the "Mound City" explorations; of the cultivation of maize and other cereals; of the early evidence of the manufacture and the use of pottery; of weaving, spinning, &c., as practised by aborigines; of ornaments in gold, silver, and bronze; of weapons of war and the chase, and how they were used; of the animals found with primitive man; of the houses he dwelt in above-ground, above-water, and underground; and, lastly, of his burying-places and religious rites for the dead.

These and a hundred other topics Mr. Stevens has brought

* 'Flint Chips: a Guide to Pre-historic Archæology.' By E. T. Stevens. London. 8vo, pp. 632. Bell and Daldy. 1870.

together in a useful form in his book, all that he says having a reference to the collections in the Blackmore Museum, yet giving sufficiently clear information upon each subject to interest the general reader who may never be able to visit this most interesting place.

The arrangement of the Blackmore Museum consists mainly of four great groups:—1. The remains of animals found associated with the works of man. 2. Implements of stone. 3. Implements of bronze. 4. Implements, weapons, and ornaments of modern savages, which serve to throw light upon the use of similar objects belonging to pre-historic times.

The mammalian remains are described by Dr. H. P. Blackmore. These consist chiefly of a local series from Fisherton, near Salisbury, associated with stone implements of the palæolithic type. "The animals," says Dr. Blackmore, "which lived in our country whilst the drift-beds were being deposited, differed strangely from those with which we are now familiar, and afford the most conclusive evidence of the greatly altered condition of our climate. The musk-sheep, reindeer, lemmings, pouched marmot, mammoth, and woolly rhinoceros are all animals peculiarly adapted for living in an Arctic clime. Our downs were tenanted by vast droves of rather small but hardy horses, not unlike the half-wild forest ponies of the present day, by large herds of deer, and shaggy-maned bisons. The stillness of the night, we may imagine, was not unfrequently broken by the terror-inspiring roar of a hungry lion, or perchance by the howling of a pack of wolves, or the hideous discord of the savage hyænas quarrelling over some half-putrid carcase—making the air re-echo with their peculiar yells."

There is good reason to believe that the Blackmore Museum, although not so extensive in every department as some of the Continental museums, is nevertheless one of the best in Europe.

But what adds perhaps the greatest value to the Collection, and what, for purposes of comparison, places it above all others, is the suite of American antiquities obtained by Messrs. Squier and Davis in their explorations of the tumuli and mounds of the valleys of the Mississippi and Ohio. This was the finest collection of its kind in the United States, and it is doubtful whether one of equal extent, and so rich in the works of primitive man, can again be made in America; indeed many of the specimens are unique. Apart from the general merit of the Blackmore Museum as illustrating pre-historic archæology in a singularly successful manner, the fact of its containing this remarkable American collection gives it at once a distinctive character, and offers a special object to reward the archæologist who may visit this ancient city—already famous for its magnificent megalithic remains at Stonehenge on Salisbury Plain, once the home of the bustard, the last of our large indigenous wild birds exterminated by man.

Part X. of 'Reliquiæ Aquitanicæ' * has come to hand since our last Chronicle was written. M. Lartet commences in this number a very admirable article on the employment of sewing-needles in ancient times, illustrated by a plate and numerous woodcuts of bone and bronze needles.

The bone needles from the caves have nearly all rounded stems, and in most cases they have been carefully polished. Narrow pieces of the hard exterior of the bone or horn were carefully isolated by parallel cuts with a flint flake, and when quite detached the splinter was rubbed into proper shape on a sandstone rubber, and polished on a skin. The eye of the needle was drilled with a pointed flint drill. Some needles figured exceed three inches in length, and, in finish, are as slender as a German-wool-work needle or large darning-needle of the present day. It is very interesting to find in the same cave with the finished needles, the half-made needles (partially cut from the horns of reindeer, the bones of a bird, the metatarsal of the reindeer, and the metacarpal of the horse) and the "wasters," also the instruments used for their manufacture, showing that the cave-folk of the reindeer period were as well accustomed to make and use the needle in the preparation of articles of dress as are the modern Esquimaux. It is also (as M. Lartet observes) but reasonable to suppose that, like the Esquimaux, they used the sinews of the reindeer for their thread, as there is equal justness in inferring that their dress was composed of the skin of these animals so abundant throughout the region of Aquitania in pre-historic times. M. Lartet thinks the long needles may have been used for embroidery, as they would have been too delicate to use for ordinary sewing or stitching of skins, for which the short stout needles seem best adapted.

An interesting account is given of the preparation of the skins by the Esquimaux, and their methods of sewing and ornamenting their dresses.

The cave-folk of the Reindeer period were quite unacquainted with the sheep, and although, like some modern aborigines, they had a prejudice against the hare and rabbit, yet they seem to have killed them for the sake of their fur, to use, it is supposed, as the Laplanders do, to trim the borders of their dresses with.

Before concluding this account, it is interesting to note that the eyed needles were not found indifferently in all the stations of that period. At Les Eyzies, Laugerie Basse, and at La Madelaine in Dordogne, the largest quantity of needles have been collected and always associated with harpoon-heads of the barbed type. It is also

* 'Reliquiæ Aquitanicæ: being contributions to the Archæology and Palæontology of Périgord and the adjoining provinces of Southern, France.' By Edouard Lartet and Henry Christy. Edited by T. Rupert Jones, F.G.S. London. H. Baillière.

with these barbed weapon-heads that similar needles have been found in the Bruniquel Cave by the Vicomte de Lastic, and in the rock-shelters of the same place, so successfully explored by M. Brun, of Montauban. They have been found in similar association in the lower cave of Massat (Ariège).

From the cave of Veyrier at the foot of Mount Salève, which belongs, like those of Les Eyzies, La Madelaine, &c., to the artistic portion of the Reindeer period, and where the antlers of this ruminant have been found having figures of animals and plants engraved upon them; needles have also been obtained, one of which appears to be made of ivory.

In the older caves, like that of Aurignac (Haute Garonne), Les Fees (Allier), and the Gorge d'Enfer, where remains of the reindeer are less abundant, and at the same time the Quaternary fauna is more completely represented by extinct species, eyed needles have not as yet been met with. Simple awls, made of bone or ivory, seem to have served in their stead, whilst the modern *barbed* type of weapon-head is not found, but in its place the older lanceolate form.

Eyed needles have been discovered in the Swiss-Lake habitations and elsewhere; but in general these needles, though belonging to times comparatively more recent, are far from being as well shaped as those of the artistic epoch of the Reindeer age.

Discovery of a Pre-historic Dwelling on the Coast of Haddingtonshire.—A short note by Mr. J. W. Laidlay, F.S.A., F.G.S., on a pre-historic dwelling and kitchen-midden, discovered by him on a small rocky peninsula near Seacliff on the coast of Haddingtonshire,* is of great interest as deciding against the theory, put forward so ably by Mr. Archibald Geikie, and subsequently by Mr. T. Smyth, that the shores of the Firth of Forth had risen at least 25 feet since the time of the Roman occupation.†

The rock in question, situated about three miles east of North Berwick, on the south side of the Firth of Forth, is isolated at spring tides, but is at other times separated by the sea from the mainland. The remains found upon the rock were, first, the foundations of an ancient building, consisting of stones selected apparently from the beach, and joined together only with earth or mud; being two or three courses in height, but concealed until recently by a thick coating of turf; secondly, a large quantity of rude handmade pottery in fragments, a number of implements of bone, such as needles, arrow-heads, combs, knives, chisels, &c., very similar in point of manufacture to those from the Swiss-Lake dwellings of the Stone period; thirdly, a vast quantity of bones of oxen (exhibiting

* See the 'Geological Magazine,' vol. vii., June, 1870, p. 270.
† See ibid., vol. ii., 1865, p. 181.

considerable variety in proportions, and including *Bos longifrons*) sheep, goats, deer, swine, dogs, &c.; of shells, in great abundance, especially those of *Patella vulgaris* and *Littorina litorea;* a very rude querne, &c. All of these have been deposited in the Museum of the Society of Antiquaries of Scotland, in Edinburgh; and are considered, by those best qualified to judge of their age, to belong to a period certainly as remote as the Roman occupation, or even earlier. This opinion is greatly confirmed by the absence of all trace of metallic implements, notwithstanding the most diligent efforts on the part of Mr. Laidlay and his sons to discover any such by having the entire soil upon the top of the rock (of which there were many cart-loads) all carefully sifted by hand.

This rock is not more, as to its lower part, than 22 or 23 feet above high-water mark. Assuming that its age extends beyond the historic period, it seems clear that, if the assumed elevation of this coast, already mentioned, had taken place since the time of the Romans, this rocky promontory would not merely have been uninhabitable at high water, but it would have been actually submerged. As it is at present, the sea in rough weather renders it hardly endurable to remain on the rock; whilst a very slight depression would enable the waves to make a clean breach over it.

Dépôt for the Manufacture of Flint Implements.—The investigation of the so-called "Devil's Pits" and "Grimes' Graves," near Brandon, Norfolk, show that the working of flint at this spot dates back to a far earlier period than the manufacture of gun-flints, now also almost a thing of the past. The bottom of the pit has been reached, disclosing a network of galleries extending into the chalk in various directions. At the end of No. 1 Gallery a fine ground-stone hatchet was discovered, and two well-worn horn-picks. These caves were doubtless pre-historic chalk-workings for obtaining flint for the manufacture of implements of which such numbers have been obtained from the river-valley gravel close by.

The early flint-implement makers of the Stone age seem to have been as fully aware of the advantage of working a freshly dug out flint as the modern gun-flint makers, a race of artisans now nearly extinct.

Ancient Kitchen-middens in the Andaman Islands.—Dr. Stolickza has lately communicated to the Asiatic Society of Bengal an account of a visit made by him to the Andaman Islands.

These islands, inhabited by probably one of the very lowest types of aborigines known, have abundant "refuse-heaps" of evident antiquity, composed of shells, bones of the Andaman pig, stones, and broken pottery. One of these mounds, which Dr. Stolickza examined at the north end of Chatham Island, was 12 feet in height, and about 60 feet in diameter; it had been long undisturbed, as

large trees were growing upon it. Besides pottery of the rudest description and stone hammers, a few polished celts and a typical arrow-head have been picked up. The mounds, so far as they have been examined, afford no evidence of human bones to support the charge of cannibalism brought against the Andamanese, whose ancestors no doubt left these middens, seeing that similar heaps are now being formed by the natives at all their favourite places of resort around the coast.

Cannibalism in Namur.—M. Spring, the Belgian anthropologist, after an examination of the cavern of Mont Chauvaux (Namur), has satisfied himself that the men, whose bones are there found mixed with those of deer and oxen, were cannibals. He further concludes that they were so from choice, not from necessity; for the roasted bones are not only those of the aged, but also of young women, boys, and infants.

Mr. Darwin mentions that the Tierra del Fuegians in times of scarcity eat the old women first and their dogs last, the former being an incumbrance, whilst the latter assist in procuring food.

Ethnological Society.

Colonel Lane Fox (March 8) read a paper "On the Opening of two Cairns near Bangor, in North Wales." One was situated on the summit of Moel Faben, and contained a cist, in which was placed an urn, together with several small dressed stones, probably arrow-heads, and flakes, worked, not in flint, but in the trap and felspathic rocks of the neighbourhood. Other worked stones were found beneath the cist. Professor Ramsay described the nature of the materials used. The second cairn examined, called Carnedd Howel, contained fragments of an urn surrounded by fragments of burnt human bones, but not protected by a cist.

The Rev. J. C. Atkinson (April 12) made a communication "On the Danish Element in the Population of Cleveland in Yorkshire." The author showed that not only many words in the Cleveland dialect, and a very large proportion of personal and local names in the district, are of Scandinavian origin, but also that many of the idioms are markedly Scandinavian. He also traced an old Anglian element in the dialect of the people.

Dr. Donovan (April 26) read a paper "On the importance to the Ethnologist of a careful study of the characters of the Brain in different Races." This was followed by one from Mr. E. B. Tylor, "On the Philosophy of Religion among the Lower Races of Mankind." The author ascribed the first ideas of religion to a belief in spiritual beings (*Animism*). The idea of a soul extended to animals, plants, and even inanimate objects. To such spiritual beings are

ascribed the phenomena of disease, especially epilepsy and mania. Trees, rivers, sun, moon, heaven, earth, &c., furnish other spiritual beings, which again are divided into favourable and harmful spirits, causes of good and evil, and thus Dualism is a fundamental principle in the religions of the lower races. The culminating notion of a Supreme Deity is well known to many of these races.

The President, Professor Huxley (May 10), delivered an address on the Ethnology of Great Britain.

He showed that the oldest accounts of the peoples of these islands prove the existence of two types of people, physically distinct—the one tall, fair, yellow-haired, and blue-eyed; the other short and dark, with dark hair and black eyes. This dark type, as exemplified in the ancient Silures, closely resembled the people of Aquitania and Iberia, whilst the fair type bore considerable resemblance to the Belgæ of north-eastern France, and what is now called Belgium. Both peoples spoke dialects of a Celtic language. Professor Huxley did not consider that the invasions of Britain really introduced a new element into the pre-existing population; it seems doubtful if the Roman occupation strengthened the fair or the dark element. The invasions of the low Dutch and the Danes strengthened the fair element.

In the paper which followed, the Rev. Dr. Nicholas endeavoured to show that "the influence of the Norman conquest on the Ethnology of Britain" was greatly gainful to the old British or Gallo-Celtic population, seeing that the Normans, so-called, were in a far greater degree Cymric and Gallo-Frankish in blood.

In his Anniversary Address (May 24) Professor Huxley spoke of the efforts that had been made to amalgamate the Ethnological and Anthropological Societies, and pointed out the desirableness of union between the several Societies having kindred objects in view.

Anthropological Society.

Two papers were read before this Society on April 5th, by Mr. Hodder M. Westropp, and Mr. C. Staniland Wake, the former entitled "On Phallic Worship," and the latter "On the Influence of the Phallic Idea in the Religions of Antiquity."

On the 19th April, Mr. Alfred Sanders read a paper "On Mr. Darwin's Hypothesis of Pangenesis as applied to the Faculty of Memory."

Mr. George C. Thompson contributed a note "On Consanguineous Marriages." From the paper and its discussion it would appear that the practice of interbreeding was not only not necessarily injurious, but *by judicious selection* an improved race of men might be obtained. The difficulty of course, is to carry out in

practice what Dr. Langdon Down is theoretically satisfied would be of enormous value to the community, men not being like race-horses or oxen.

Major W. Ross King, on May 3rd, communicated an account of the "Aboriginal Tribes of the Nilgiri Hills," known as the Todas, Khotas, Erulas, and Kurumbas, especially noticing the former as the most singular and important. The author described the characteristic features and peculiarities of each; their social customs and religious rites, showing that even in a limited area, like the Nilgiris, several tribes may exist, each preserving its own language and customs; and all remaining perfectly isolated from the enormous populations of the plains. The presence of Druidical circles, cromlechs, kistvaens, and tumuli, on the Nilgiri Hills, offers a striking resemblance to those of our own country, and suggests the possibility of an early western migration of pre-historic peoples from this cradle of the East.

On the 19th May a large gathering of anthropologists and their friends took place at St. James's Hall, to hear Mr. Henry F. Chorley's paper "On Race in Music." Mr. Dannreuther illustrated the paper by numerous examples on the pianoforte.

On the 31st May, Dr. John Shortt read a paper "On the Armenians of Southern India;" and Mr. John Stirling "On the Races of Morocco."

The Ancient Cemetery at Frilford.*

Almost the only source of information we possess capable of being used either to check off, or to throw light upon, the early history of our Romano-British and Anglo-Saxon ancestors—a well-nigh pre-historic epoch in this country—is derived from a study of the early graves and barrows scattered over this island far and wide, many of which have yielded evidence of the highest import to the historian, archæologist, and ethnologist.

In the paper before us, Professor Rolleston has given a most complete and exhaustive memoir upon the remains obtained by him during a two years' exploration of the ancient burying-place at Frilford, near Abingdon, Berkshire.

The cemetery is situated in the angle between the left bank of the river Ock and the road leading from Frilford to Wantage. Frilford "Field" is now brought under cultivation, but the tra-

* Although this subject barely comes within the scope of this Chronicle, it is inserted here on account of its connection with Anthropology.

'Researches and Excavations carried on in an Ancient Cemetery at Frilford, near Abingdon (Berkshire), in the years 1867 and 1868.' Communicated to the Society of Antiquaries by George Rolleston, M.D., F.R.S., Linacre Professor of Anatomy and Physiology in the University of Oxford. 1870. 4to. [Reprinted from the 'Archæologia,' vol. xlii., pp. 417–485.]

dition that this portion of it is haunted still survives in the recollections of the rustics, one of whom told Dr. Rolleston that, although he had never seen one himself, ghosts were supposed to be particularly likely to be seen at a single thorn-bush which stood some time back close to the site of these graves.

Dr. Rolleston is not the first who has devoted his attention to this fruitful spot. Mr. Akerman had, in 1865, furnished an account of excavations in this same locality to the Society of Antiquaries.

But the present is by far the most complete and exhaustive memoir yet published, giving, as it does, a careful account of the exhumation in a more or less complete state of 123 separate individuals, probably the largest number ever yet examined by any one savant from a single locality. The exploration of the ground has resulted in the discovery of Roman remains in lead coffins, Romano-British remains in ordinary graves, and Anglo-Saxon skeletons having ornaments associated with them belonging to that period, also undoubted Anglo-Saxon cinerary urns containing half-calcined human bones. Dr. Rolleston has discovered that these numerous interments, representing several separate periods of time, are also placed at different levels in the soil, the Anglo-Saxon cinerary urns having been so slightly interred as to have, in one instance, been actually cut by the ploughshare.

In spite of the ravages of fire, in the cases of cremation, and the all but equally destructive working of the water, containing carbonic and other acids, upon inhumation in ground with the rock (Coralline Oolite) within an average distance of about a yard from the surface, it has been found possible to identify the sex and age in all but about a sixth of the skeletons, or parts of the skeletons examined. Many skeletons, however, and many urns have been lost to science during the various quarrying operations carried on previously to Mr. Akerman's report in 1865.

Great numbers of Roman coins have been and still are found by agricultural labourers, when at work, all round this spot; and also fragments of very many varieties of Roman pottery. There is much other evidence to show that Roman civilization had taken firm root in this locality; for not only have three or four Roman leaden coffins been found containing human skeletons and coins (of Constantine jr., Valens, and Gratian, A.D. 383), but about a couple of hundred yards distant from the cemetery, having observed the greater greenness and strength of the crops upon two patches of ground, Mr. William Aldworth, the liberal owner of the soil, permitted the ground to be opened with the result of finding for a depth of ten feet or more, an aggregation of fragments of pottery of the most varied patterns and degrees of fineness mixed up with similarly fragmentary bones of the ox, sheep, pig, and dog, and with other articles, such as a key, a spoon, knives, a bronze ring, a

hair-pin, coins, &c., which, like the bones and shards specified, would be expected in the rubbish-heap of a great house. The site of the house Mr. Rolleston did not find, but he thinks the quarry, whence the stones for its construction were taken, was converted afterwards into, and is now represented by, one or other or both of the rubbish-pits.

Professor Rolleston has given most carefully-prepared lists of all the remains found in the various graves which he divides into those :—

In leaden coffins (Roman period), 6.
Romano-Britons, 31 men, 22 women.
Supposed Anglo-Saxons (but without relics), 3 men, 3 women.
Anglo-Saxons, with relics or in urns, 21 individuals.
Other skeletons, 15. Children found without relics, 23.

One of the most striking peculiarities of this series is the very large proportion of aged persons; but a closer inspection shows that the proportion varied most surprisingly in accordance with the nationality. Out of the undoubted Anglo-Saxon interments only two could have been considered old. This may have resulted from the mortality inevitable in the ranks of all successful invading armies, especially such undisciplined troops as composed the Saxon hosts.

The preponderance of aged Romano-British skeletons may be not only the result of more settled conditions, but may also be explained, Professor Rolleston thinks, by the hypothesis that the young men had been taken away to fight and die in distant countries under such commanders as Magnus Maximus.

This state of things is well understood in France and elsewhere, where conscription is practised in time of war.

In discussing the variations in the series of skulls exhumed at Frilford the author well remarks that "most or all invasions entail more or less of intermarriage between the invaders and the invaded; and the craniographer who considers what very motley hordes passed into England under the names of 'Roman' and 'Saxon' respectively, and for what long periods these immigrations continued to be made, will be cautious as to his inferences."

We might follow Professor Rolleston through the detailed account of this laborious investigation; the subject is one of deep interest, but we have said sufficient to show the import and nature of the author's researches, and to commend him as a sure and experienced guide, both in archæological and ethnological inquiries. To those who have not seen the Oxford Museum, the fact of its being the depository for this wonderful series of remains may serve as a further inducement to pay it a visit.

3. ASTRONOMY.

(*Including the Proceedings of the Astronomical Society.*)

The attention of astronomers is becoming more and more directed towards the preparations which are being made for observing the total eclipse of December 24th next. There seems every reason to believe that the English corps of observers will be far more effective than any which this country has hitherto sent to observe a total eclipse. Spectroscopy, photography, and polariscopy, will be entrusted to the charge of those who are best fitted to superintend the details by which these modes of research can alone be rendered successful. As yet the arrangements have not been fully decided upon, though they will probably be known before these pages are printed. At present it is understood that there will be two expeditions, one to Spain, the other to Sicily. Each will consist of about thirty persons; and each will include, besides one or two general observers, three distinct parties, the spectroscopic observers, the observers with the polariscope, and the photographers. It has been proposed that the three parties forming the Spanish expedition, should be headed respectively by Mr. Huggins, the Rev. C. Pritchard, and Mr. Browning. As regards the parties forming the Syracusan expedition, it has been proposed that Mr. Lockyer should head the spectroscopists, and Mr. Brothers the photographers, the polariscopic department not having as yet been assigned to any specified chief.

Everything promises well for the success of these expeditions, since we learn from Lieutenant Brown, whose long residence at Gibraltar renders his opinion especially valuable, that the weather is, on the whole, more likely to be clear and settled in December than in any other month of the year. The Poet Laureate has volunteered to join the expedition, and we may perhaps hope to have from his pen such a description of a total eclipse as will be at once worthy of the subject and of his powers.

The observers must not forget, however, that nothing but the utmost care and the most thoughtful consideration beforehand of all the difficulties they are likely to be troubled with, as well as of all the methods by which they may secure reliable results, will serve to render the expedition successful. It must be remembered that the points to be determined—the nature and structure of the corona—are questions of extreme difficulty and delicacy, which have already foiled the exertions of the able astronomers who have observed the last two total eclipses. During the present eclipse totality will not last more than half as long as during the eclipse of 1869, and scarcely one-third as long as during the eclipse of 1868. It will tax the powers even of the skilful observers about to take part in

this important work, to learn something new about the corona during the two minutes of total obscuration.

The discovery that the star Eta Argûs, around which the most amazing nebula in the whole heavens spreads itself in fantastic convolutions, is shining with the light of burning hydrogen, is, perhaps, when rightly understood, the most instructive fact which has been revealed by astronomical observation for many past years. We know that this star is now nearly at its minimum of brightness, and astronomers confidently expect that in the course of the next half century it will rise from its low estate as a sixth-magnitude star until it again outblazes even Canopus in splendour. That this star, like the new star which lately shone out in Corona, is surrounded by hydrogen-flames, seems clearly established by the observations of Mr. Le Sueur at Melbourne. He has not been able, indeed, to test the character of the bright lines across the star's faint continuous spectrum, by actually bringing them into juxtaposition with the lines of hydrogen. But he has been able to measure their position with considerable accuracy. He finds, by spectroscopic observation, that the space around the star is really free from nebulous light, and is not merely dark by contrast; and he deduces the conclusion that the star has been fed, so to speak, by the matter of the nebula, since the nebulous light which appears at some distance from the star exhibits one of the hydrogen bright lines. This view may well be demurred to, since it would render the restoration of the star's light a simple impossibility. And besides, when Sir John Herschel observed the star in 1837, the nebula was bright all round the star; whereas, since the star was then shining very brightly, the nebula should have shown signs of having been consumed near Eta Argûs, were Mr. Le Sueur's theory correct. It seems far more probable that the amazing variability of this nebula is due to the motion of its parts, and is associated with the equally amazing variability of Eta Argûs in such sort that, when a rich region of nebulous matter is brought to the star's neighbourhood the star becomes bright, while when, as now, the star is surrounded by a region bare of nebula, its light sinks low.

One fact, at any rate, seems placed beyond all question by Mr. Le Sueur's researches. We can scarcely doubt any longer that the nebula and the star are intimately associated, or that the strange variation of one is but the counterpart and measure of the variation of the other.

Mr. Browning's invention of the automatic spectroscope is full of promise for the advancement of our knowledge of the constitution of the celestial bodies. This is not the place to enter into a consideration of the advantages it presents over all other forms of the spectroscope; but our Chronicle would have been incomplete without a few words of comment on this most ingenious addition to our means of

research into the physical habitudes of the orbs which people the celestial depths.

Professor Kirkwood's ingenious hypothesis that the periodicity of the solar spots may be referred to the existence of solar regions favourable to the development of spots, has received its death-blow at the hands of Sir John Herschel. Our veteran astronomer is still ready to devote his great powers to the study of such questions. In this case he has been at the pains to mark down the exact place on the sun's *globe* of all the spots observed by Carrington. He finds no trace of a region where sun-spots occur with unusual frequency, or if there are traces of such a region they are so slight as to afford no sufficient foundation for Professor Kirkwood's hypothesis.

Professor Kirkwood's detection of the law that comets of small perihelion distance have their perihelia nearly in the direction towards which the sun is travelling, has been followed up by a careful investigation of the periods of some of the meteoric rings. The April shower, though less familiarly recognized than the November and August showers, is yet too well marked not to be admitted among the periodical meteoric systems. Professor Kirkwood shows that this system cannot be associated, as Weiss suggested, with the first comet of 1861; but by comparing the dates on which remarkable showers of meteors belonging to this system have appeared, he exhibits the probability that the system has a period of $28\frac{1}{3}$ years, and an aphelion distance very nearly equal to the mean distance of Uranus. Dealing with the meteors of December 11–13, he finds for them a period of $29\frac{1}{3}$ years. For the meteors of October 15–21, he obtains a period of $27\frac{1}{2}$ years. He adds, "if these periods are correct, it is a remarkable coincidence that the aphelion distances of the meteoric rings of April 18–20, October 15–21, November 14, and December 11–13, as well as those of the comets, I. 1866 and I. 1867, are nearly all equal to the mean distance of Uranus." As Jupiter has his family of dependent comets, so distant Uranus has depending from his orbit a family of meteoric and cometic systems. Can we suppose that those among these meteor-systems which intersect the orbit of the earth are all which thus depend on Uranus, or that they form a thousandth or even a millionth part of his family of meteor-systems? The laws of probability are enormously against such a supposition; and if it be indeed true (as we seem forced to admit) that around the orbits of the major planets there cling these myriads of meteoric and cometic systems, we obtain a new insight, indeed, into the characteristics of the solar system.

Saturn will continue to be favourably visible during the ensuing quarter. Mars, Venus, and Jupiter will be unfavourably situated. We remind our readers to look out for shooting-stars on the nights of August 9–13.

There will be a total eclipse of the moon, visible at Greenwich, on July 12. The first contact with the penumbra will take place at 7h. 46m. P.M., first contact with the shadow at 8h. 45m. Totality will commence at 9h. 44m. and end at 11h. 24m. Last contact with the shadow will take place at 12h. 24m., last contact with the penumbra at 1h. 22m. on the morning of July 13. On July 27th there will be a partial eclipse of the sun invisible at Greenwich.

Proceedings of the Astronomical Society.

Lieut. Herschel, in a paper on "Dark Objects crossing the Solar Disc," describes how he was for some time deceived into the belief that a flight of meteors was crossing the sun's face on October 17–18, 1869; but at length discovered that the objects he had been watching with so much attention were locusts.

Mr. Proctor contributes a paper "On the Solar Corona and the Zodiacal Light," with suggestions respecting observations to be made on the total solar eclipse of next December. He exhibits a series of arguments for rejecting the view put forward by Mr. Lockyer that the sun's corona is due simply to atmospheric glare, showing in particular that that portion of the sky on which the corona is projected during total eclipses corresponds to a portion of the atmosphere which is absolutely unilluminated by the sun. He gives reasons for believing the corona to be simply the condensed part of the zodiacal light. Remarking on Dr. Balfour Stewart's recent suggestion that the zodiacal light may be a terrestrial phenomenon, he points out that the trade-wind region (to the illumination of which by electric discharges Dr. Stewart ascribes the zodiacal light) occupies (above the horizon-plane of any station) a lamina shaped like a watch-glass, and the whole of this lamina (in other words, the whole sky) should be illuminated if the theory were correct. Were the zodiacal light caused in this way, a "tongue-shaped slip" only of this lamina would be illuminated; and admitting this to be a possible arrangement at any time, we have yet no explanation of the fact that this slip always occupies a region near the ecliptic, or that it rises and sets with the stars. Among the suggestions put forward respecting modes of observing the eclipse, there is one which, remembering the very short duration of totality, seems to be worth consideration. When totality begins, the eye, accustomed to a brighter light, is unable to accommodate itself to the darkness of totality, nor does totality last long enough to admit of a change in this respect. If, however, the eye were kept in darkness before totality commenced, there seems little doubt that the observer would be able to employ much more effectually the two

minutes of total obscuration. This remark applies not only to general observation, but in an especial manner to those extremely delicate spectroscopic and polariscopic observations which are required in the present instance.

Captain Noble, observing Venus near her inferior conjunction, found the body of the planet projected very distinctly as a dark disc on a light background. "The difference of tint from that of the surrounding sky was evident," he says, "the instant Venus was regarded." This observation, though not new, deserves special attention just now that the nature of the solar corona is being so much inquired into. It shows beyond all possibility of question that there is some light which comes from regions beyond the planet; in other words, that there is just such illumination beyond Venus as we should expect to find if the corona is a solar appendage. It seems amazing that in the face of such evidence—with Venus actually projected as a dark disc on *some* illuminated region beyond her—any astronomer should believe the light of the corona to come from the glare of our atmosphere some hundred miles or so, at farthest, from the earth.

Mr. Browning invites attention to farther changes in the form and colour of Jupiter's belt. The ochreish-yellow which had been so marked during the winter months of 1869 had, on January 31, become much fainter and of a duskier hue, being also confined to the northern part of the equatorial belt, instead of covering the whole of it as had before been the case. On March 10th, he found the tawny-yellow colour again extending over the whole of the equatorial belt, which had become broader than he had ever before seen it. This belt had a very dark band on the south, and a narrower dark band on the north; beyond each of these being a brilliant white belt. It will be interesting when the planet again returns to our skies (towards the end of the year) to observe whether the striking outbreak of colour has passed away or increased. The planet will not rise to a great height on the meridian, but the correcting eye-piece ingeniously contrived by Messrs. Airy and Simms will render observation at low elevations a very different matter from what it used to be.

At Mr. Hind's suggestion, Mr. Plummer, of Mr. Bishop's Observatory at Twickenham, has re-examined the orbit of the comet of 1683. He has been able to show that, instead of the ellipse calculated by Clausen, the orbit of the comet is probably parabolic or nearly so, so that there is very little probability that this famous comet will quickly return to the sun's neighbourhood.

Professor Wolf has continued his researches into the solar spot-period. He finds that the observations made in the years 1864–69 supply clear evidence in favour of his theory that the spot-period is one of $11\frac{1}{9}$ years. But the most interesting part of his communi-

cation is that which has reference to the relation between the variation of the magnetic declination and the frequency of solar spots. In 1859, Professor Wolf had proposed the following formula for this variation (v) at Christiania:—

$$v = 0'{\cdot}0413\, r + 4'{\cdot}921,$$

where r is the "relative number representing sun-spot frequency." The following Table, in which v represents the calculated v' the observed variation, indicates what cannot but be regarded as a very satisfactory confirmation of this formula:—

	1864.	1865.	1866.	1867.	1868.	1869.
v	6′·87	6′·26	5′·64	5′·25	6′·58	8′·39
v'	6·00	5·72	5·70	5·69	6·65	7·82

The observations of the magnetic variation were communicated to Professor Wolf by Messrs. Mohn and Fearnley. It will be seen at once that the minima of the two series closely accord. Doubtless, with the progress of observation, the empirical formula stated above will have to be slightly modified.

Mr. Birt supplies further notes on the visibility of the spots upon the floor of the lunar crater Plato. It seems too difficult to separate the different qualities of vision, the various conditions of the atmosphere, and still more the peculiarities of different telescopes, from the variations of visibility considered by Mr. Birt, to form any satisfactory conclusion on the subject.

Professor Cayley supplies two valuable papers on the geometrical theory of solar eclipses. The mode in which he treats the subject is too rigidly mathematical to admit of being presented in these pages. It may be remarked, however, that in his first paper he discusses, in a most lucid and interesting manner, the problem of determining the stereographic projection of the curve of two dimensions which is the intersection of a cone and a sphere, showing that this projection is a bicircular quartic.

4. BOTANY.

Cross-fertilization.—Dr. Ogle has continued his observations on the various contrivances in the structure of the flower to promote cross-fertilization. The purpose of the nectary is to attract insects; any noticeable irregularity of the corolla is also usually connected with the visits of insects, compelling them, when in search of the nectary, either to impinge on the anthers or on the stigma, and thus carry the pollen from one flower to another. Adrien de Jussieu had remarked the connection which exists between the presence of nec-

taries and the irregularity of the flower, but had not discovered the reason of this connection. To speak of the tufts of hair-like papillæ which are often found on the pistil as collectors of pollen for the purpose of the self-fertilization of the flower, is clearly erroneous; their position shows that their use is the very opposite, serving to sweep the pollen out of the way in order to prevent it from reaching the stigma. Instead of *poils collecteurs*, by which term they are known in French manuals, *poils expulseurs* would be a better name for them. The heads of flowers of the order *Compositæ* usually begin to expand at the circumference, the expansion then extending to the centre. As a general rule the anthers are ripe before the stigmas (*protandry* of Hildebrand); the pollen, therefore, of the inner flowers fertilizes the pistil of the outer flowers; hence the outer flowers of the ray are generally destitute of stamens. Dr. Ogle finds that in *Papilionaceæ* cross-fertilization is the rule; and that the peculiar form of the stamens in *Erica*, *Vaccinium*, *Arbutus*, and other genera of the same order, contributes to this end.

Fertilization of Ferns.—Dr. E. Strasburger contributes a paper on this subject to Pringsheim's 'Jahrbuch für wissenschaftliche Botanik.' He commences the account of his experiments by tracing the development of the antheridia, or cells which produce the spermatozoids, from their earliest condition, and states that the growth of their lateral cells presents the first example in the vegetable kingdom of annular cell-formation by division. The new twin cells, a central cell and the annular lateral cells, are distinguished from ordinary cells by the differences of their contents, the inner one being stuffed with granular protoplasm, the outer ones containing at first an almost colourless sap, with a single scarcely discernible nucleus, and a few scattered grains of chlorophyll. After escaping from the antheridium, the spermatozoids, corresponding to the pollen of flowering plants, enter into the central cell of the archegonium, or female organ, by a peculiar twisting motion, and there meet with and fertilize the germ. A large number of the spermatozoids will enter a single cell, forming a kind of chain, but fertilization appears capable of being effected by one only.

Turning of Plants towards the Light.—M. Duchartre contributes to a recent number of the 'Comptes Rendus' an account of a remarkable growth of fungi in a garden at Meudon (Seine et Oise). They were found growing in a hollow place beneath a reservoir kept constantly full of water, in perfect darkness, but in a comparatively high temperature. At the end of September, on the lower surface of this reservoir were found more than 500 individuals of a small Agaric belonging to the genus *Coprinus*. They were all towards the southern part, springing from the roof of the cavity, with their head downwards. The stem of every individual had departed from the vertical by an angle of at least 30°, their

direction being towards the north. The circumstances seem to contradict the prevalent theory that the deflection of plants from the perpendicular is due either to the force of gravity, or to a desire to seek the light.

Sensitiveness of the Mimosa.—In the 'Mémoires de la Société des Sciences Naturelles de Strasbourg,' M. Millardet details some new and elaborate researches on the periodicity of the "tension" in plants, especially in the *Mimosa pudica*, or sensitive plant. The amount of "tension" is greater by night than by day, but undergoes various oscillations of two kinds, which he terms periodic and paratonic oscillations. The periodic oscillations are either long or short, the longer lasting for twenty-four hours, and attaining their maximum towards the end of the night, and their minimum towards the middle of the day; the shorter periodic oscillations lasting about an hour, and occurring both by day and night. The paratonic oscillations are due to differences in light, temperature, moisture, and other causes, and are more pronounced by day than by night; they are intermediate in duration between the longer and shorter periodic oscillations. All these movements occur in both stem and leaves. The motor organs of the leaves consist of tissues which are subject to variations of tension, and the movements are but an expression of these variations.

Variegation and Double-flowering.—It had long been laid down as a maxim by botanists that variegation of the leaves and doubling of the flowers (conversion of stamens into petals) never go together; and although recent writers had doubted the universality of the law, it was difficult to point to any authentic instances of the two phenomena occurring together. Professor E. Morren, of Liége, has, however, set the matter completely at rest by a description in the 'Belgique Horticole,' accompanied by a drawing, of a double wallflower with variegated leaves, which has been successfully grown for some years by M. Rodigas of St. Trond.

Irritability of Stamens.—M. Jourdain * has been trying experiments on the effects of chloroform on the stamens of *Mahonia*, which are excitable like those of the barberry, springing back against the pistil when irritated. When enclosed in a glass bell, in which was placed some cotton, on which a few drops of chloroform had been sprinkled, at the end of one minute the stamens were strongly thrown back as if in a tetanic state, and resisted all attempts at excitation. Exposed again to free air, after eight or ten minutes the irritability reappeared, at first feebly, and completely after the lapse of twenty-five or thirty minutes. If the action of the chloroform is continued for ten or twelve minutes the flower assumes an orange tint, and the stamens do not recover their sensibility on exposure to the air; the next day they become black.

* 'Comptes Rendus,' April, 25.

Acclimatization of Palm-Trees.—In addition to the date-palm and the *Chamærops*, which have long been naturalized on the European shores of the Mediterranean, M. Naudin has succeeded very well with several other kinds at Collioure, in the Pyrenees, notwithstanding the exceptionally unfavourable character of the winter of 1869–70. The severe cold of the last week of December, when the thermometer descended to – 4°, and in some localities even to – 6° C., was fatal to only one species. The extraordinarily heavy fall of snow which took place in January, lasting for forty-four hours without intermission, was expected to destroy the young trees altogether. After, however, they had been entirely covered up with snow for nine or ten days, so that the boughs were completely flattened, when the thaw came they almost immediately recovered their former position, even the green colour of the leaves not being injured. The same fall of snow caused a fearful amount of destruction among the olives and cork-oaks.

Mimetic Plants.—At a recent *soirée* of the Linnean Society a very interesting set of foliage-plants was exhibited by Mr. W. Wilson Saunders, arranged in pairs, the plants of each pair bearing such a striking resemblance to one another in the general character of the foliage, and even in the venation of the leaves, as to be with difficulty distinguishable from one another, and yet belonging to entirely distinct natural orders, not in any way related to one another. Mr. Saunders states that none of the plants were grown for the purpose, but were selected on the spur of the moment from his collections; and he has little doubt that if attention were drawn to the subject, such a collection might be indefinitely increased.

Parasitic Fungi.—In several recent numbers of the 'Zeitschrift für Parasitenkunde,' edited by Dr. E. Hallier, instances are recorded of diseases of the ear resulting in deafness being caused by minute parasitic fungi. The most certain cure appears to be the external application of spirits of wine.

Recent and Fossil Copal.—At the meeting of the Linnean Society, held May 5th, Dr. J. D. Hooker read a communication from Dr. Kirk, Her Majesty's Vice-Consul at Zanzibar, on the distinction between the recent and fossil states of the resin known in commerce as Copal. One characteristic by which fossil copal is known from the recent resin is the so-called "goose-skin." Dr. Kirk has ascertained that the fossil copal shows no trace of this goose-skin when first dug out of the earth, but that it makes its appearance only after cleaning and brushing the outer surface. Both descriptions often contain imprisoned leaves, flowers, and insects in a beautiful state of preservation; but the fossil variety is clearer and more transparent. Captain Grant states that the true copal gum-tree is a climber reaching to a great height among the forest trees, finally becoming completely detached from its original root, when the copal exudes from

the extremities of these detached roots. Large pieces of the resin fetch a very high price even in that country.

New Species of Jalap.—Mr. Daniel Hanbury contributes to the 'Journal of the Linnean Society' a description of a hitherto undescribed Convolvulaceous plant, which he names *Ipomæa simulans*, being the plant the root of which furnishes the article known in commerce as Tampico Jalap. It is obtained from Mexico, and has been extensively brought into the market; and though it is less rich in resin and less purgative than true jalap, yet, on account of its lower price, it has found a ready sale, chiefly in the Continental trade.

5. CHEMISTRY.

It has long been a disputed question whether a small quantity of phosphorus improves or injures the mechanical properties of steel. M. L. Gruner has carefully examined this subject, and has arrived at the result that phosphorus present in steel in a quantity of from 0·002 to 0·003 causes the metal to be rigid; it tends even to increase the elasticity and the resistance to breaking, but does not modify the hardness. Such steel, however, is wanting in real strength and toughness; it is brittle (*aigre*), that is to say, does not withstand shocks. The general result is, therefore, that even very small quantities of phosphorus present in steel do not only not improve, but certainly deteriorate, its good qualities. Dr. Salet, the chief assistant to Professor Wurtz, has arranged an ingeniously constructed apparatus to detect the smallest possible quantity of phosphorus in iron and steel, by means of the spectrum produced by the combustion of the hydrogen obtained by the action of chlorhydric acid on the metal.

Since the internal use of amylic alcohol, even in small quantities, is very deleterious, the means of rapidly testing for its presence in spirits and alcohol (either for pharmaceutical or scientific use) is of importance. The suspected alcohol is poured into a burette, mixed with its own bulk of rectified and pure ether, and also its own bulk of water, and the mixture gently shaken; the ether, on becoming separated from the rest of the fluid, floats to the top, containing in solution the whole of the amylic alcohol which might have been contained in the alcohol or spirits under examination. The ether is removed by a pipette, and on leaving it to spontaneous evaporation, will leave behind the amylic alcohol, readily detected by its offensive odour.

The absence of oxygenated water from snow which fell at Rouen has been shown by M. A. Hozeau. He has tried some very careful experiments to detect the presence of peroxide of hydrogen in water

obtained from snow, care being taken to prevent the loss or decomposition of the peroxide alluded to. The author's opinion is that, since the experiments made at Kasan undoubtedly proved the presence of the peroxide of hydrogen in snow-water, there may exist an essential difference, caused by the locality where it falls. Kasan is situated almost in the centre of the Russian empire, far away from any seas or oceans.

On the other hand, Professor H. Struve has ascertained the presence of peroxide of hydrogen in air. His chief results are, (1) peroxide of hydrogen is formed in air simultaneously with ozone and nitrate of ammonia, and is condensed in the rain-water; (2) peroxide of hydrogen, ozone, and nitrate of ammonia, are intimately connected together; (3) the change which the so-called ozone-paper undergoes when exposed to air is due to the joint action of ozone and peroxide of hydrogen; (4) peroxide of hydrogen does not decompose solution of iodide of potassium with separation of free iodine; (5) free carbonic acid decomposes the solution of iodide of potassium, causing the formation of carbonate of potassa and free hydriodic acid; (6) when the peroxide of hydrogen is present along with carbonic acid (acting as just alluded to), iodine is separated; (7) the best and most effective reagent for the detection of small traces of peroxide of hydrogen is oxide of lead, since puce-coloured peroxide is formed.

According to J. Jouglet, nitro-glycerine, dynamite, iodide of nitrogen, chloride of nitrogen, and some other similar compounds, explode the very moment they are brought into contact with ozone; so that, for instance, a drop of nitro-glycerine, introduced into a vessel containing ozone, causes an instantaneous explosion. Picrate of potassa gunpowder, and ordinary gunpowder, are slowly decomposed by ozone, a decomposition which, as regards the last-named substance, takes several weeks before it is perceptible.

Under the name of Albolith, Dr. Riemann prepares a cement chiefly consisting of magnesia For this purpose, the magnesite of Frankenstein (Silesia) is ignited in retorts similar to those used for gas-manufacture; and after the mineral (a native carbonate of magnesia) has been ignited, it is mixed with silica and some other substances. This mixture has the property of yielding, with moderately concentrated solutions of chlorides (for instance, chloride of magnesium), an extremely plastic, but, on drying, a very hard material, excellently adapted for use as cement for stucco and ornamental work, and instead of gypsum.

In a research on Isinglass, J. L. Souberain states that the different varieties of this article, as met with in the trade, may be recognized as follows:—Russian isinglass dissolves rapidly and instantaneously in hot water, leaving hardly ever more than at most 2 per cent. insoluble residue; Bengal isinglass dissolves readily,

but leaves from 7 to 13 per cent. of residue. The taste of Russian isinglass is pleasant and sweet; it yields a very firm gelatine, which is perfectly transparent. The Bengal, or Indian kind, often has a fishy taste, and the gelatine it yields is not clear. The Brazilian isinglass yields an opaque, milky-looking gelatine, and its taste is acrid. China isinglass is a rare article in the European markets.

An important reaction in synthetical chemistry has been published by Dr. E. Royer, who has effected the formation of formic acid from carbonic acid. The author states that, while submitting to the action of a current of electricity an aqueous solution of carbonic acid, the latter was simply converted into formic acid by the addition of hydrogen.

Owing to the fears of a quinine famine expressed some years ago, great efforts were made to introduce the cultivation of cinchona trees in numerous new localities. We have recently heard of the first importation of cinchona bark from Java, a quantity of some 930 lbs. of this bark having been exported from Java to the Netherlands. According to analysis made by Dr. B. Moens in Java, this bark contains from 2·4 to 7·5 per cent. of alkaloids, of which quantity 0·59 to 3·67 is quinine. The loss of weight occasioned by the drying of the bark has been found to amount to 66 per cent. There is every prospect that within some six or seven years hence Java will largely export this drug; and the cultivation of the cinchona trees is also to be extended to Sumatra, Celebes, and the Moluccas.

Dr. Loew has made known a fact which renders still more probable the Hydrogenium theory of the late Professor Graham. The researches of Graham went to show that hydrogen could be alloyed with palladium, and that it was also contained in meteoric iron. He condensed the hydrogen in the palladium, and came nearer proving its metallic character than any other person had done. Dr. Loew has succeeded in combining hydrogen with mercury. He takes an amalgam composed of not more than 3 or 4 per cent. of zinc, and shakes it with a solution of bichloride of platinum; the liquid becomes black, and a dark powder settles to the bottom. The contents of the flask are then thrown into water and hydrochloric acid added to dissolve the excess of zinc. The amalgam of hydrogen and mercury at once forms in a brilliant voluminous mass, resembling in every way the well-known ammonium amalgam. It is soft and spongy, and rapidly decomposes, but without any smell of ammonia. The hydrogen escapes, and soon nothing but pure mercury is left in the dish. The experiment appears to show that an amalgam of hydrogen and mercury can be formed, and that hydrogen is really a metal.

Now that the analysis of air—physical and chemical—is attracting so much attention, it may be of some interest to know what

substances the New York Metropolitan Board of Health found in the air of the opera-houses. Over one hundred specimens of the particles floating in the air, and falling as dust, were collected on plates of glass, and examined under the microscope. The proportions of the different ingredients varied, but the same substances were found in all the specimens. The composition of the matter subjected to the microscope was as follows:—The dust of the streets in its finer or coarser particles, according to the height at which it had been collected, with a large proportion of organic elements; particles of sand, quartz, and feldspar; of carbon, from coal-dust and lamp-black; fibres of wool and cotton of various tints; epidermic scales; granules of starch of wheat; the tissues of plants, mainly the epidermic tissue, recognized by the stomata or breathing pores; vegetable ducts and fibres, with spiral markings; vegetable hairs or down, either single or in tufts of four or eight, and of great variety, and three distinct kinds of pollens. Fungi were abundant, from mere micrococcus granules to filaments of mould. When water was added to a portion of dust from whatever source, and exposed in a test-tube to sunlight or heat for a few hours, vibriones and bacteria made their appearance, and the fungous elements sprouted and multiplied, showing that they maintained their vitality, and proving that the germs of fermentation and putrefaction are very widely diffused. In connection with this subject, it is right to mention here that Mr. Samuelson performed a similar series of experiments six years ago, on dust from all parts of the world.*

All lecturers who have tried to float and then ignite an explosive balloon will be glad to know the following easy means of effecting this difficult but striking experiment devised by Mr. Patterson. At first the author tried the india-rubber balloons of the toy-shops. From various causes they had failed; but the chief difficulty was doubtless the tension which made it difficult to secure the gases. Recently the author's attention has been directed to the collodion balloons, obtainable from the philosophical instrument makers, believing that they would suit well, both on account of their lightness, and on account of the fact that they would wholly disappear on ignition. After a number of trials he has found them to succeed admirably. The method adopted is as follows:—

A fuse of filter-paper, about 1 inch long and ½ inch broad, is gummed to the side of the balloon near the mouth, and allowed to dry. The latter is then filled with a mixture of 2½ volumes of hydrogen gas and 1 volume of oxygen, the mixture being prepared in a separate vessel. The mouth of the balloon is at once tied with a piece of thread to increase the force of the explosion. When the balloon is ready to ascend, a drop of the so-called "Greek fire"

* See 'Quarterly Journal of Science,' July, 1864.

(that is, a solution of phosphorus in carbon disulphide) is placed on the filter-paper; the thread is cut and the balloon left to itself. In the course of half a minute or so the explosion ensues. It is necessary to have an excess of hydrogen in the mixture, because exosmose takes place so rapidly that, by the time of ignition, the volume of that gas is sensibly reduced.

6. ENGINEERING—CIVIL AND MECHANICAL.

In our last number we gave, under the above heading, a brief account of narrow-gauge railways, which, during the period therein referred to, had engaged considerable attention both in this country and in Russia. The necessity for improving the means of local transit has, since then, continued to receive the consideration of all most interested in the question; and a "Tramways' Bill" has recently passed through the Legislature, in which provision is made for facilitating the construction and laying of tramways on common roads.

Street Tramways.—Tramways for passenger traffic have for some time past been in operation in New York, Boston, Washington, New Orleans, and they are becoming general in all the more important towns of the United States. Paris, Genoa, Vienna, Copenhagen, and Brussels, have all their tramways for passenger traffic, and they have also, for some years, existed in Liverpool along the Dock sides. Some years since iron rail tramways were introduced into London, but after a short trial they were ordered to be removed in consequence of the obstructions they caused to ordinary vehicles. At the East End of London a granite tramway has been in existence for many years, extending from the western end of the Commercial Road East to the West India Dock; and in a circular by Mr. J. B. Redman, dated in March last, on the subject of Metropolitan Tramways, it is stated that "practically the tramway is in as efficient working a state as it was twenty years back." The late Mr. Walker conducted certain experiments with granite tramways in 1829, which showed that a powerful draught-horse could draw a load equal to 30 tons upon a level, at the rate of four miles an hour; and in his report on the subject he said, "The friction is not more than upon the best constructed edge railways. I consider that the greater size of our wheels, and there being no flange, compensates for the roughness of the stones (from their being newly laid) as compared with an iron railway."

Whilst fully alive to the advantages of tramways for lessening friction, attention has not yet been sufficiently given in this country to the improvement of our macadamized roads by rolling; and now

that steam road-rollers have been brought to such perfection, the operation is much simplified. Road rolling has for more than a quarter of a century been officially applied over the whole extent of the French and Prussian roads, which are kept up under centralized State superintendence, and perhaps one of the strongest arguments in its favour may be given in the words of the surveyor of the roads near Coblentz, in Prussia, who has observed that as "everywhere in Prussia and in France the highways are rolled, if the systems were not good the expense would not be incurred." Space will not admit of our entering further into this subject now; the whole question has recently been very ably and fully discussed by Mr. F. A. Paget, C.E., in a pamphlet entitled 'The Economy of Steam Road-rolling,' to which we would refer our readers for further information on this head.

The recent movement in favour of tramways in London has resulted in the construction, by the Metropolitan Street Tramways Company, of two short lines, together about four miles in length, the one at Brixton and the other between Whitechapel and Bow. The tram adopted by this Company, and which may class, perhaps, as the best in form hitherto introduced for the purpose, consists of an iron groove fixed level with the surface of the paving, on which the flange of the omnibus wheel travels. The lines are double, and between them as well as in the space between the trams, and strips on either side of about 20 inches wide, the ground is paved with granite sets. The plan of the road, which consists of longitudinal wooden sleepers laid upon concrete, admits of the repair of the tramway, by lifting up lengths of tram and sleeper, without breaking up the road beyond the width of the tram (four inches), and a few stones here and there to undo the fastenings.

Single Rail Permanent Way.—Amongst other novelties of recent introduction, and which come under the category of "Tramways," we may mention two projects for single-line rails. The one by Mr. W. J. Addis, of Tannah, near Bombay, has already been put into practice in India, where it is reported to work very favourably. In this case the rail is intended to be laid down either upon any existing line of road, or on roads made especially for the purpose of a tramway. One of the advantages claimed for this kind of line is that ordinary carts may run upon it, the only necessary alteration being the addition of a central wheel, or wheels, according to the length of the vehicle; the additional wheels being attached to the bottom of the platform of the carts, and having a flange on either side to prevent any moving off the rail. These wheels work on a swivel attached to a screw, by means of which the ordinary side-wheels are raised slightly off the road, so that the whole weight of the vehicles rests upon the central rail.

The second single-rail project to which we have referred was

designed by M. J. Larmanjat, and was first carried out by him in a short trial line, constructed between Raincy and Montfermeil in the summer of 1868. According to M. Larmanjat's system, the tramway is constructed with a single central rail, and along a good road this constitutes the whole of the permanent way. The locomotive employed to haul the trains has four wheels, the two driving wheels, placed on either side, resting on the ordinary surface of the road, and a leading and trailing wheel, having grooved peripheries, and which are situated on the centre line of the machine, bearing upon the central rail. The carriages have also four wheels, arranged in a similar manner, but whilst in the engine the greater weight rests on the side driving wheels, in the case of the carriages the adjustment of the springs is such that the chief weight rests upon the wheels running on the central rail, the other wheels merely serving to steady the vehicle.

Wire Tramway.—Another improved method of cheap tramway construction is found in Hodgson's Wire Tramway system, a specimen of which, five miles in length, has recently been constructed in the immediate vicinity of Brighton. One respect in which this differs from other tramway projects is its unfitness for passenger traffic, it being principally applicable for the conveyance of mining produce and goods generally. Hitherto it has mostly been employed by the French beet-root growers to carry the roots from the field to the storehouses. This tramway consists of a strong iron wire, running over rollers supported on posts, having brackets extending on either side. The greatest length to which one rope line is usually applied is five miles, and a succession of such lengths would be required for any greater distance. At each end of the line is placed a horizontal wheel, around which the rope turns, and at one end is placed an engine for giving motion to the wire. The truck employed consists of a kind of shallow box without a lid, suspended from the wire by means of a bent arm, so arranged that the saddle which rests on the wire is immediately over the centre of the truck. The rope being put in motion, these trucks are caused to run upon it, and are carried forward with it. Where a long line is required, suitable arrangements are made by which the trucks run from one wire on to the next, and so on.

Meetings of Societies.

Institution of Civil Engineers.—Space will not admit of more than a passing remark on the most important papers read at this Institution. On 8th March, Mr. D. M. Fox read a "Description of the Line and Works of the San Paulo Railway in the Empire of Brazil." The line is 88 miles in length, and was constructed at a total aggregate cost of 1,861,667*l.* It runs over low swampy

ground for the first $13\frac{1}{2}$ miles, and then rises to a height of 2500 feet by means of inclined planes of 1 in 10, worked by stationary engines. From this summit, for a distance of 68 miles, the line crosses a succession of short ridges and valleys, with occasional deep cuttings and embankments A description of "The St. Pancras Station and Roof, Midland Railway," was read by Mr. W. H. Barlow on 29th March. As this work has already been noticed in this Journal, we shall not give any further account of it now. "The Maintenance and Renewal of Railway Rolling Stock," by Mr. R. Price Williams, on 12th April, is a most important and interesting paper, but it is so filled with statistics and figures as to render any short abstract impossible. On May 3rd, Mr. George Berkley read a most important paper "On the Strength of Iron and Steel, and on the Design of parts of Structures which consist of those materials." And on 24th May two papers were read, the one by Mr. George Fowler, "On the Relative Safety of different modes of Working Coal," and the other, "On Coal Mining in Deep Workings," by Mr. Emmerson Bainbridge.

Institution of Mechanical Engineers.—At a general meeting of this Institution, held on 28th April, amongst other business a paper was read "On a Steam Road-Roller." This roller was 25 tons weight, and 9 feet wide; it could roll an area of 300 square yards per hour, with a consumption of coal of about 1 cwt. per hour. The adhesion was found sufficient for gradients as steep as 1 in 9.

South Wales Institute of Engineers.—On the 5th May, at the usual general meeting of this Society, held at Newport, Monmouthshire, discussion was resumed on Mr. J. Brogden's paper "On the Comparative Merits of large and small Trams for Colliery Use," and "On Bernard's Coal-Washing Machine." A paper was also read "On the Application of Blast of a High Temperature to Blast Furnaces of moderate Elevation," by Mr. Thomas Whitwell.

The New York Society of Practical Engineers.—A well-timed paper was read on 20th April last by Mr. C. Williams, "On the Old and New Methods of City Transit," in which a history was presented of the various methods from time to time attempted to facilitate locomotion in cities and towns; and the paper wound up with a description of a method of applying compressed air to locomotive purposes.

Literature.

'Report on the Maritime Canal connecting the Mediterranean at Port Said with the Red Sea at Suez,' by Captain Richards, R.N., F.R.S., Hydrographer to the Admiralty, and Lieutenant-Colonel Clarke, C.B., R.E., Director of Engineering and Architectural Works, Admiralty. This report has been published by Govern-

ment, and coming as it does from officers of such high authority, after a personal inspection of the Canal, it possesses a peculiar national interest not to be found in similar works by independent individuals on the same subject.

'Principles and Construction of Machinery; a Practical Treatise on the Laws of the Transmission of Power, and of the Strength and Proportions of the various Elements of Prime Movers, Mill-work, and Machinery generally; arranged for the use of Students, Engineers, and Practical Mechanics,'* by Francis Campin, C.E. The aim of the author is stated in the preface to have been "in the first place to explain the fundamental theories of mechanism in the clearest and briefest manner, so as to impress upon the mind *general principles*, not special cases, and then to show the practical developments of such theories, care being taken to arrange the matter as to try the faculties of the mind as little as possible." This text appears to have been well adhered to, and the result has been the production of a book calculated to prove of great use to the classes for whom it has been written.

7. GEOLOGY AND PALÆONTOLOGY.

(Including the Proceedings of the Geological Society and Notices of recent Geological Works.)

In the 'Philosophical Transactions '(1869), p. 445, will be found a most valuable contribution to the Fossil Flora of North Greenland, being a description of the plants (collected by Mr. Edward Whymper during the summer of 1867) by Professor Oswald Heer.

The greater part of the fossil plants which have been brought from Arctic regions have come principally from one locality, Atanekerdluk, in (lat. 70° N.) North Greenland. Here, however, they occur in such profusion that we are able, to some extent, to restore the ancient flora, and deduce most important conclusions as to the former condition and climate of this high northern region. The fossil plants brought home by M'Clintock, Inglefield, and Colomb, and deposited in Dublin and London, were found at this locality, also the very rich collection made by Mr. Olrik (formerly Inspector of North Greenland), and now deposited at Copenhagen. These materials were found upon examination to contain 105 species of plants. Of some the leaves, fruits, and seeds were observed, so that an absolute determination of their species was rendered possible; while of others merely the leaves, and of these, at times, only fragments, were discoverable. Of these latter therefore the identifications cannot be considered as final.

* London: Aitchley and Co.

Mr. Whymper's collection contains, on the whole, 80 species of plants from North Greenland; 32 of these are new for this flora, and 20 are quite new. The Miocene plants of North Greenland have thereby reached the number of 137 species, and those of the Arctic Miocene flora 194. Of these 137 species from Greenland, 46 agree with those of the Miocene of Europe. The systematic position of a number of plants from North Greenland is as yet uncertain; but the number positively identified is so large, that it enables us to give a sketch of its Miocene flora. Of the fossil plants from Disco Island there are 14 species: of these, *Aspidium Meyeri*, *Sequoia Couttsiæ*, *Platanus Guillelmæ*, and *Magnolia Inglefieldi* are most widely distributed. The plane and the *Sequoia* are the commonest trees; to these may be added a *Widdringtonia*, a *Liquidambar*, and a *Magnolia* with large evergreen leaves. Two cones of this *Magnolia* having been obtained, they corroborate the determination of this tree originally effected by means of the leaves alone.

A *Dryandra*, an *Aralia*, and a *Paliurus* probably constituted the brushwood of the forest, whilst several species of ferns covered the ground. The *Phragmites* and the *Sparganium* point to the existence of a river or a lake. Of the 73 species from Atanekerdluk, 25 are new. Five of these are found in the Miocene flora of Europe, *viz.*:—*Poacites Mengeanus*, *Smilax grandifolia*, *Quercus Laharpii*, *Corylus insignis*, and *Sassafras Ferretianum*. The oaks appear very frequently at Atanekerdluk. The southern limits have been determined as follows:—Six species stop at the Baltic coast; ten occur in Switzerland; seven in Austria; four in France; seventeen in Italy; six in Greece; four are common to North Greenland and Bovey Tracey in Devon. It is certainly very interesting to find so many species extend to Italy and Greece. Almost all these may be referred to the country situated between these two extreme limits, and we thereby see that our knowledge respecting the Miocene flora of Europe, at least the forest-plants, is no longer so imperfect as heretofore. Dr. Heer's paper contains descriptions of all the species collected, and is illustrated by eighteen 4to plates of the fruits and leaves determined.

On *Palæocoryne, a genus of Tubularine Hydrozoa from the Carboniferous Formation.**—This new and remarkable little fossil, representing the first of its class, is introduced to the Royal Society under the guarantees of Dr. P. Martin Duncan, F.R.S., &c., Sec. Geol. Soc., and Henry M. Jenkins, F.G.S., Sec. Roy. Agric. Soc. It was obtained from the lower shales of the Carboniferous limestone series of Ayrshire and Lanarkshire, which is very fossiliferous in many places, and is also remarkable for the perfect condition in which the organic remains found therein have been

* 'Phil. Trans.,' 1869, p. 693.

preserved. In these shales numerous small pedunculated radiata (whose external appearance differs from that of any extinct organism hitherto discovered) are found, usually attached to the margins of the polyzoarium of *Fenestellæ*, or in a more or less fragmentary condition amongst the small pieces of broken Polyzoa and Crinoid stems which compose the fossiliferous layers of the shale.

The attachment is by a dactylose base, which, when broken or cut, is proved to be cellular internally. The base contracts as it increases in height, and is continued upwards in the form of a cylindrical stem, which is faintly enlarged in its middle portion, and which is surmounted by a symmetrical structure resembling a reversed obtuse cone, the margin of whose base is prolonged into several tentacular processes, which are arranged in one whorl, and are long, slender, and tapering. The upper surface of the body is granular, and the stem is ornamented with longitudinal flutings and minute processes. The general appearance is that of a long straight-armed star-fish reversed and fixed on a stiff stem with an expanded base. The authors enter carefully into the minute anatomy; they then proceed to show why it is inadmissible as an Echinoderm, a Polyzoan, or a Zoantharian, and finally, through having so remarkable a calcareous investment, they show that by the aid of the anomalous living genus *Bimeria* (Wright) they are able to overcome the difficulty and refer it to the Hydrozoa. It is therefore placed in the class Hydrozoa and in the Order *Tubularidæ*, of which it will constitute a new family and at present a singular genus. Two species are described and figured by the authors. It is extremely probable that other new and interesting forms may be discovered in these shales, but hardly possible that anyone will be able, like the authors of this paper, to light upon a new class of fossils.

Mr. W. T. Blanford, F.G.S., late Geologist to the Abyssinian Expedition, has given us the result of his observations on the Geology and Zoology of Abyssinia, made during the progress of the British Expedition to that country in 1867–68.*

The author was detached from the Geological Survey in India in 1867, and started for Abyssinia.

The formations met with throughout the region traversed were: —1. **Recent**: consisting of soils of the highlands, including "regur," or cotton-soil, similar to that found in India, and alluvial deposits on the coast. 2. The volcanic series, which skirts both coasts in the southern portion of the Red Sea. This group, which is but poorly developed on the west coast of Annesley Bay, Mr. Blanford proposes to call the Aden Volcanic series. 3. Trappean series. This grand collection of beds, which forms the Abyssinian highlands, including Magdala and the Ashangi groups, consists of two divisions,

* Macmillan and Co.: London, 1870.

which are unconformable to each other, the former (the Magdala group) consisting of trachytes and dolerites, and the latter (the Ashangi group) entirely composed of dolerites of great thickness and bedded volcanic rocks, lavas, and ashes. Through this Trappean series, near Bethor, not far from Magdala itself, the Jitta River has cut its way and now runs at a depth of 3500 feet, in a valley probably more than a mile in width. The sides are extremely steep, often perpendicular. The beds on both sides appear exactly to correspond. A well-marked river-terrace, half-way down, indicated on both sides of the stream, records the fluviatile origin of the gorge. Of all the grand scenery, says Mr. Blanford, met with in Abyssinia, none equalled this wonderful gorge. His descriptions remind one of the Grand Cañons of the Colorado River. 4. "The Antalo limestone" is of Oolitic age, and contains *Ceromya similis, Trigonia costata*, and other characteristic fossils, reminding one strongly of British forms. 5. "Adegrat sandstone," a massive formation, occupying a very extensive area in northern Tigre, and perhaps representing the coal-bearing rocks known to exist north-west of Lake Dembea, but yielding no fossils. 6. Metamorphic rocks of various mineral character, with a general north and south strike, due to pre-existing cleavage.

The author describes the scenery as being almost everywhere most strikingly beautiful, now bold and romantic, now resembling the undulating character of Western England. Some of the illustrations are very remarkable and striking, the plateau-like disposition of the tops of all the hills reminding one strongly of the Sinaitic peninsula, as if the same meteoric agencies had carved out the valleys from an originally highly elevated, but unbroken plain. The recent natural history part of the work is ably dealt with by Mr. Blanford, and the book will well reward the zoologist, and even the ordinary reader of travels.

Several Geological Survey Memoirs have made their appearance in the present quarter. From the Geological Survey of England and Wales we have,—'A Memoir on the Geology of the Carboniferous Limestone, Yoredale Rocks and Millstone Grit of North Derbyshire and adjoining parts of Yorkshire,' by Messrs. A. H. Green, C. Le Neve Foster, and J. R. Dakyns, with an Appendix on the Fossils by R. Etheridge. Secondly, 'The Triassic and Permian Rocks of the Midland Counties of England,' by Edward Hull, F.R.S., &c.

From the Indian Geological Survey we have Part I. vol. vii. of the Memoirs, 'On the Vindhyan Series, as exhibited in the North-western and Central Provinces of India,' by Frederick R. Mallet, F.G.S.; No. I. of Records (1869), 'The Valley of the Poorna River, West Berar,' by A. B. Wynne, F.G.S., &c.; also Part I. vol. viii. of the 'Records of the Indian Survey for 1870.' In this last-men-

tioned publication is Dr. Oldham's Report for 1869, in which the Director sets forth not only the labours accomplished by his comparatively small staff, but also sketches out their projected labours for 1870. In speaking of the enormous area which the Indian Survey has to traverse, Dr. Oldham remarks, "I have always found it exceedingly difficult to lead to a just conception of the immensity of the areas we have to deal with in this country, and it may be useful to draw a comparison here which may tend to a realization of the facts. The small map, which accompanies Mr. Mallet's Report (a reduction from the larger scale maps used in the field), the title of which we quoted above, represents an area quite as large as England and Wales; while all the lines of geological division and subdivision shown on it have been actually traced out by detailed examination.

The previous Part of the Memoirs (the last Part of vol. vi.) contained also a geological map of quite as extended an area; that is to say, geological maps and reports have been published within twelve months, exhibiting the structure of a country larger in area than the whole of Great Britain and Ireland; and to this should be added that the maps relate to a country, regarding the structure of which nothing trustworthy was known previous to the Geological Survey commencing their labours.

Two other papers appear in the same Part, namely, "Notes on the Geology of the Neighbourhood of Madras," by R. Bruce Foote, F.G.S., and "On the Alluvial Deposits of the Irawadi, more particularly as contrasted with those of the Ganges," by W. Theobald, jun., Esq.

Under the title of 'Eminent Living Geologists,' the Editor of 'The Geological Magazine' has published an account of Professor Adam Sedgwick, of Cambridge, and Mr. G. Poulett Scrope, F.R.S.: both these gentlemen have attained to the highest honours in geological science, and have contributed largely towards its literature. The former, as the Woodwardian Professor of Geology in Cambridge, has delivered fifty-two courses of lectures in the University; the latter is the well-known author of the 'Volcanoes of Central France,' published so long ago as 1827, and of many other works on Volcanoes, &c. Both notices are accompanied by well-executed portraits.

In the same journal Professor Huxley gives us the results of his examination of *Palæotherium magnum*;* Professor T. Rupert Jones, the South Wales *Entomostraca*;† Professor de Koninck, of Liège, some new Palæozoic Echinoderms;‡ Professor Harkness, of Elephant-remains in Ireland.§ Mr. James Croll accounts for the Boulder-clay of Caithness; Mr. Charles Lapworth explains the Geology of Galashiels; Mr. Henry M. Jenkins, the Geology of

* P. 153. † P. 214. ‡ P. 248. § P. 253.

Belgium; Mr. Allport writes on the Basaltic Rocks of the Midland Coal-field; The Rev. T. G. Bonney, on *Pholas*-Burrows; Mr. J. W. Judd, on the use of the term Neocomian, &c., &c. There are also the usual Geological Notices, Reports, &c.

'The Quarterly Journal of the Geological Society' contains papers by Messrs. R. Tate and J. S. Holden, on the iron ores associated with Basalts in the North-east of Ireland; Principal Dawson, of Montreal, on the Structure of *Sigillaria*, and on some new Animal-remains from the Carboniferous and Devonian of Canada.

Mr. J. W. Hulke makes known a new Crocodilian skull from Kimmeridge Bay, Dorset, which he has named *Steneosaurus Manselii;* and some teeth associated with two fragments of jaw, from the same locality, which he has provisionally named *Euthekiodon.*

Mr. Etheridge describes the Geological Position and the Geographical Distribution of the Reptilian or Dolomitic Conglomerate of the Bristol area, from which were obtained the remains of *Thecodontosaurus* and *Palæosaurus*, Dinosaurian reptiles about which more has yet to be made known.

Mr. Wilson sketches out the surface-geology of Rugby, and Mr. Lloyd does the same for the Avon and Severn Valleys.

Mr. Moore's (postponed) paper upon Australian Mesozoic Geology and Palæontology, makes us acquainted with a large number of new Australian fossils (chiefly obtained from erratic blocks, of the parentage of which nothing is at present known). These remains are, however, many of them very unsatisfactory for purposes of determination. Mr. Moore considers they are comparable with our Lower Lias types. The part is a bulky one, and is illustrated by nine 8vo and two 4to plates.

The Ancient Relations of Land and Water.—Professor Huxley's address last quarter to the Geological Society has such vast importance for the zoologist that we must allude to it here. It forms the starting-point of a scientific study which hitherto has been suffering for want of some sound and comprehensive speculation to which workers may bring their facts, which may be taken as the basis of operations, and enlarged, modified, and improved in various directions. The question suggested by a consideration of the distribution of living organisms on the earth's surface is, not only what forms have we in this or that locality, but *how* did they get there? Did A come with B or with C; did they all come together or separately? It is this examination of the faunæ and floræ of various regions which Professor Huxley enters on, and broadly sketches out the various ways in which in past times the terrestrial animals of the different areas at present recognized may have arrived there. By fully following out this line of study, we may one day be able to assign its proper history to every species of animal and plant, and to trace the wan-

derings of its forefathers from one region to another, and their gradual modifications of form. In looking at our English fauna, we may hope to recognize certain forms as belonging to our area from Palæozoic times, others as dating from Mesozoic, others again as Eocenic, others as Miocenic or later; in some cases we shall assign such an age to the order or genus, and a later age to the specific modification. Professor Huxley conceives that distinct provinces of the distribution of terrestrial life have existed from the earliest periods—earlier than those of which we have any record. Whilst in the dry land of our own area during Carboniferous times *Amphibia* existed, in some other terrestrial provinces of that period *Birds*, *Reptiles*, and *Mammalia* may have been developing. The Permian epoch marks the beginning of a new period, and during the Trias dry land existed in North America, Europe, Asia, and Africa, as it does now. The mammals, birds, and reptiles developed in the preceding epoch spread into this great continental area called Arctogæa. Depression then commenced in parts, and special developments occurred in various regions. At the early part of this period, Professor Huxley conceives Australia to have been separated and to have remained dry land ever since. The discovery of the remarkable Australian Ganoid since his address, confirms his conclusion. The Mesozoic continent was probably continued across the Pacific area to what is now the province of Austro-Columbia, the characteristic fauna of which dates from this period. At a later part of the Mesozoic period, upheaval of the Atlantic shore and depression of the Pacific caused a westward movement of the Vertebrate fauna which took possession of new lands and increased in extent up to the Miocene epoch, from which period we may clearly trace all the Mammalian forms characteristic of the great continental area of our present world—exclusive of South America, Australia, and New Zealand. From the Devonian period to the present day, the four great oceans—Atlantic, Pacific, Arctic, and Antarctic—may have occupied their present positions and only incessantly changed their channels of communication and coast-lines.

The attempt in this address to follow back the origin of Vertebrate forms of life, needs only to be succeeded by similar efforts with regard to Invertebrate groups, and more especially as to plants, the same method of comparing present distribution and past, as far as it is yet known, being used, and we shall ultimately attain most valuable conclusions as to both Geological and Biological history.

The palæontology of the greater part of the earth has yet to be investigated in order to bring light on this matter.

8. METEOROLOGY.

The most important paper which we have to notice in this number is one by Dr. Julius Hann, "On the Climate of the Upper Regions of the Alps," which appears in the 'Journal of the Austrian Meteorological Society.' The Swiss stations are situated in many instances at considerable heights above the sea. Five of them are at a level exceeding 6000 feet. The station of Hoch Obir, in Carinthia, is at a similar height. However, the information derived from these points gives us hardly any knowledge of the climate prevailing above the snow-line, and the difficulties which presented themselves in the way of obtaining accurate observations from such an elevated region seemed almost insurmountable, until they were overcome by M. Dollfuss. This gentleman succeeded in persuading three Swiss guides to spend an entire year, from August 1865 to August 1866, on the Pass of St. Theodule, under the Matterhorn. The level of this station is all but 11,000 feet above the sea.

The barometrical observations were made three times a-day, while those of temperature, wind, and weather, were recorded eleven times daily.

The first point on which Dr. Hann touches is the extreme of cold registered, which he finds to be only 6°·5 F. The winter of 1865–6 was a warm one, but still the temperature just cited is unexpectedly high for so elevated a station, considering that much greater cold has been experienced at lower stations in Europe nearly on the latitude of the Pass in question, *e. g.*, – 12°·5 at Geneva in January, 1838, and – 20° at Prague in 1830. We need not refer to the intense frost felt in corresponding latitudes in America, where, in the State of New York, the mercury has been known to freeze.

The self-registering minimum thermometers, which have been placed on the summits of so many mountains by the members of the Alpine Club, have not yielded results at all commensurate with the labour of depositing them in their resting places and subsequently reading them, so that we are driven to the ordinary records at high levels to find a confirmation of the minimum observations at St. Theodule. It is found to be universally true that the extremes of cold are registered not on the summits of the mountains but in the valleys where the chilled air collects.

The winter climate was on the whole cold, as the thermometer never rose above 32° from November to April, but the weather was very enjoyable notwithstanding. At the high level of their station the observers found the intensity of the solar heat on a calm day to be so great that they frequently were sitting in the sun in their shirtsleeves, when the thermometer in the shade was close to zero F. They often noticed the snow melting when the observed temperature was

2 F 2

7° or 8° F., and even on the peak of Mont Cervin itself they more than once saw traces of a thaw.

As a compensation for the unlooked-for mildness of the winter climate, the summer at the station was extraordinarily cold. The mean temperatures of the three summer months was 32°·3, and that of July, only 33°·5. These are the lowest average summer temperatures that have ever been reported; for the mean of Dr. Kane's stations in Smith Sound was 35°·4 for the summer, and 39°·9 for July. It is well known that at Yakutsk and other stations in Siberia, as well as in North America, where the winter temperature is excessively low, the heat of the summer is comparatively high, approaching and even surpassing that observed in these islands. The result is that a rapid and vigorous, though short-lived, vegetation is produced.

It is hopeless to look for anything of this nature on the Pass of St. Theodule, where frost occurs every night. The perpetual sunshine of an Arctic summer effectually prevents any damage to the growing plants from this cause.

The annual march of temperature at high stations is remarkable. Comparing the observations now under discussion with those from other stations at somewhat lower levels, Dr. Hann finds that February is the coldest month, sometimes even March, while December is extraordinarily mild. In this month it is found that the temperature increases with the elevation owing to the accumulation of cold air in the hollows.

This fact shows the great difficulty of determining accurately the decrease of temperature with height, in any district, the local conditions which influence the result being so very various. However, the Swiss observations throw some light upon it, and Dr. Hann has submitted to the Academy at Vienna a paper on the subject, in which he has calculated provisionally a table to show the rate of this decrease. From this paper we learn that the level of the isothermal contour of 32° varies from 1100 feet in January to upwards of 11,000 in July. If we look for an annual temperature of 0° F., which is about that of Rensselaer Harbour, we find it to lie about 2000 feet over the top of Mont Blanc, while the lowest July temperature at sea level, that of Northumberland Sound, is met with at the level of 10,000 feet in the Alps.

Comparatively little is said about the other meteorological elements. The barometer is dismissed with a few words; but as regards the distribution of moisture the author goes into more length. In winter the air on the mountain tops is dry and clear; in summer it is much more cloudy. The action of the "courant ascendant" is analogous to the foregoing, for the mornings are much less commonly cloudy than the afternoons. As to the actual amount of precipitation at the upper stations, as compared with the lower, there is not much to say. The data for rain and snow are

very uncertain, but on the whole much less fell on the Pass of St. Theodule than might have been expected. The heaviest fall of snow recorded was only 2 feet deep, while in many of the Alpine valleys a depth of 6 or 7 feet is not uncommonly known to fall in the space of twenty-four hours.

The same journal contains a paper by Dr. Dellman, "On the Electricity of Clouds," being one of a series of papers on atmospherical electricity. Our space will only allow us to give some of the most important conclusions. They are as follows:—

All clouds are electrified, and oppositely so in different parts of the cloud.

As far as the observations at Kreuznach go, they prove that all clouds have a negative centre surrounded by positive bands or zones.

The density of the electricity diminishes towards the circumference, but the maximum density is not at the centre.

A cloud can only give rain by the occurrence of an electrical discharge.

With reference to meteorology in Russia, a report has been drawn up by a Committee of the Academy of St. Petersburg on the organization of the system. The most important suggestion which it contains is, that the empire should be divided into separate districts, with a central observatory furnished with self-recording instruments in each. Three of these establishments are now in existence. St. Petersburg; Helsingfors, for Finland; and Tiflis, for the Caucasus. Taschkend is designed as the central station for Turkestan. To these thirteen others are to be added. These institutions are to be quite independent of each other, each being surrounded by its own auxiliary stations, and publishing its own results.

Professor Mohn, of Christiania, has brought out a paper "On Sea-temperatures between Iceland, Scotland, and Norway," based in part on the observations of the Scottish Meteorological Society, and illustrated by charts for the four seasons and for the year. The isothermal curves, at all seasons except the summer, exhibit very sharp bends pointing north-eastwards. Professor Mohn calls the line joining the summits of these curves the thermal axis of the district, inasmuch as on either side of it the temperature decreases. This thermal axis lies parallel to the coast of Norway, at a distance of about 120 miles, excepting in the summer months, when the warmest water is found in the Cattegat, and the thermal axis is only traceable along a line running from the North Cape towards Spitzbergen. This thermal axis indicates the course of the Gulf Stream in these waters, which is rapidly cooled in its progress northwards, on the one hand by the ice in the neighbourhood of Iceland, and on the other by the cold mainland of Norway.

The last number of the 'Journal of the Scottish Meteorological Society' contains a very suggestive paper by Dr. R. Angus Smith

"On Chemical Climatology," or, in other words, on the impurities of atmospherical air. In addition to the ordinary analysis of the gaseous constituents of the atmosphere, Dr. Smith proposes to collect and determine the foreign matter suspended in it. In dry weather, or in covered places such as hospital wards, he shakes some water in a large bottle, containing about a gallon of air, and renews the air as often as necessary. In wet weather he collects rain. The preliminary results are very interesting from a sanitary point of view, but their general bearing is more chemical than meteorological. The author hopes "to be able to tell plainly and authoritatively if a place is close or otherwise; and to say that the rain or the air when washed must not show more than a given amount so as to be fit for respiration. In this way it may be possible authoritatively to fix a limit to the density of population, and the extent to which manufactures may be carried on within a given area." The large amount of solid matter in specimens of rain collected in Glasgow leads Dr. Smith to connect the fact with the great mortality of that town. We are glad to see that a more extensive investigation of the subject is being undertaken, and that rain is being collected at many different stations to be subsequently analyzed by Dr. Smith.

Mr. Buchan gives a preliminary paper "On the Rainfall of the South of Scotland," which is chiefly of local interest, as the rain-gauges are very unevenly distributed over the country. The driest district is the lower part of Teviotdale, where Jedburgh reports 21·99 inches; while the greatest fall is on Ettrick Pen, at a height of 2268 feet, where 71·73 inches were collected. However, the observations on hill-sides show most clearly that no law of increment with height can be assigned—the conditions of rainfall are dependent to so great an extent on the lie of the hills. The fall in the South of Scotland is far less than that in the West Highlands, owing to the fact that Ireland drains the south-west winds of much of their moisture.

The last few numbers of the 'Proceedings of the British Meteorological Society' do not contain many papers of interest. The forty-eighth number is entirely taken up with a paper by Mr. Glaisher "On the Daily Rainfall at Greenwich for the last Fifty-five Years." Although the period is so long, the numbers vary very much from day to day, and the irregularities are not eliminated even by grouping the results for periods of 5, 10, 15, 30, 60, 90, and 120 days. The only practical conclusion arrived at is, that all the periods of least rainfall occur during the first three months, and the heaviest between the months of June and December. The graphical representation of the results gives a very irregular curve. The absolute minimum of daily fall occurs about the end of March, between the eightieth and ninetieth day of the year, and the absolute maximum is noticed in the last half of October, between the 290th and 300th days.

9. MINERALOGY.

To determine with accuracy the true nature of those colouring matters which, although present in extremely minute proportions, nevertheless impart to many of our gems much of their value and their beauty, is a task which has often sorely taxed the resources of the mineralogical chemist. It is still an open question, for example, whether the green tint of the emerald is due to the chromium which the mineral contains, as originally suggested by Vauquelin, or whether it is referable to the presence of certain organic constituents detected in the emerald by M. Lewy. Towards a solution of this question a contribution has recently been published by M. J. Boussingault,* who has had at his disposal more than a couple of pounds of the amorphous emerald from the celebrated mines of Muzo, near Santa-Fé-de-Bogotà, in New Granada. In the carbonaceous schist two kinds of emerald are found—known respectively as *canutillos* and *morallones*—the former being crystallized, transparent, and of great value, while the latter are uncrystallized, less translucent, much fissured, and comparatively valueless: it was, of course, a kilo of the latter that found its way to Boussingault's laboratory. Whilst Lewy has asserted that the emerald becomes opaque and colourless by calcination, Boussingault finds that nothing of the kind takes place with the morallon: the green colour is preserved at a bright red heat, but the mineral suffers a loss of nearly 2 per cent., consisting partly of water and partly of carbon. The water is regarded as existing in a state of chemical combination, since it is not expelled below a red heat, while the carbon is probably derived from the admixture of small particles of the schist in which the mineral occurs, and from which not even the finest crystals are altogether free. On the whole, Boussingault agrees with Wöhler, G. Rose, and Vauquelin, in attributing the colour of the emerald to the presence of oxide of chromium.

It is now several years since Tschermak first enunciated his celebrated theory on the constitution of the felspars, in which he showed that the several species may be regarded as isomorphous mixtures of the two extreme types—albite and anorthite. Some difficulty has lately arisen through Vom Rath's analysis of a Norwegian felspar, regarded as Labradorite, whose composition did not fit in with the theory. Tschermak thereupon called the analysis in question, and asserted that no labradorite could exist free from soda. This proposition has called forth some ingenious observations on isomorphism by Dr. Kenngott.†

* "Analyse de l'Émeraude Morallon des Mines de Muso, Nouvelle-Grenade."—'Annales de Chimie et de Physique,' 1870, p. 328.

† "Ueber den Isomorphismus verschieden zusammengesetzter Körper."—'Journ. f. prakt. Chemie,' 1870, p. 77.

Kenngott assumes that two minerals are strictly isomorphous if the ratio between the number of atoms of metal and of oxygen is the same in the two compounds. Now, albite and anorthite may both be reduced to the general formula: $4\,RO.6\,RO_2$ where the ratio of $R:O = 10:16$. For our author takes the liberty of writing the formula of albite in this fashion: (Na_2O, Al_2O_3) $(6\,SiO_2)$; and that of anorthite in this wise: $2\,(CaO.AlO)$ $(2\,SiO_2.AlO_2)$. Extending this mode of formulating the silicates, he shows the possibility of the existence of a compound containing $CaO.SiO_2 + Al_2O_3.2\,SiO_2$, for such an expression may be thrown into the form $(CaO.AlO)$ $(3\,SiO_2.AlO_2)$, which is now referable to the general type $2\,RO.4\,SiO_2$. Such a compound would be, as Tschermak observes, a labradorite free from soda, but we see at once that it is not isomorphous with albite. We forbear to follow Kenngott's interesting suggestions farther, as they lead across the border-land of chemistry.

In the third number of the new Italian Geological Journal—a journal which we welcome as a fair sign of scientific progress in Italy—Professor Bechi publishes some analyses of minerals from Sig. Foresi's collection.* His examination of some fine limped crystals of beryl from the isle of Elba, show that they are remarkable for containing cæsium, and for holding more alumina and less glucina than other beryls. Traces of lithium were also detected by the spectroscope. A black tourmaline from the granite of the isle of Giglio—an islet rising from the waters of the Tuscan Sea—has also been analysed; and for the sake of economizing space we place the composition of the two minerals side by side:—

Beryl.		Tourmaline.			
Silica	70·00	Silica	36·71	.. Magnesia	0·49
Alumina ..	26·33	Alumina ..	31·57	.. Soda ..	2·83
Glucina ..	3·31	Ferric oxide	8·51	.. Potash ..	0·70
Cæsium	0·88	Ferrous oxide	9·39	.. Boric acid	5·56
Oxide of iron	0·42	Lime	0·64	.. Fluorine	1·85

Two substances physically distinct, but occurring together near Brevig in Norway, have hitherto been confounded under the general name of *Esmarkite*. One of these is a true Praseolite, but the other is an extremely rare mineral, which has received Des Cloiseaux's attention during his visit to Norway.† This acute crystallographer has carefully examined authentic specimens of the true Esmarkite, and pronounces it to be merely a laminar variety of the felspar—anorthite.

Several new species recently described demand a cursory notice. *Glaucopyrite* is Professor Sandberger's name for a new mineral, obtained from Guadalcanal in Spain, and consisting of an arseniosulphide of iron, in which part of the iron is replaced by cobalt and

* "Analisi chimiche di alcuni minerali delle isole del mare toscano."—'Bollettino del R. Comitato geologico d'Italia,' 1870, p. 82.
† 'Ann. d. Chim. et de Phys.,' 1870, p. 176.

copper, while part of the arsenic gives place to antimony.* Herr Boricky describes, under the name of *Zepharovichite,* a new species allied to Wavellite occurring in the sandstone of Trenic in Bohemia.† Tschermak proposes the name of *Simonyite* for a salt lately found at Hallstadt, closely related to Blœdite, from which it differs, however, in being stable when exposed to the air.‡ Finally, Dr. Schrauf applies the name *Simlaite* to a mineral from Simla in India, similar to meerschaum, but containing alumina, and belonging to the group of halloysites.§

Two Cornish minerals have lately been analyzed by Professor Church—the one a variety of kaolin, akin to lithomarge, and termed *Restormelite;* the other is the beautiful green mineral known as *chalcophyllite,* or copper-mica.‖ The formula of restormelite may be written $Al_2O_3 . 2\ SiO_2 + 2\ aq.$; while the composition of the chalcophyllite may be thus expressed: $8\ CuO . Al_2O_3 . As_2O_5 + 24\ aq.$

Attention is directed by Mr. S. G. Perceval ¶ to the occurrence of topazes in the granite of Lundy Island, somewhat similar to the well-known crystals from the granite of the Mourne mountains. The writer of this Chronicle has for several years past been familiar with specimens of both topaz and beryl from Lundy.

Professor How follows up his 'Contributions to the Mineralogy of Nova Scotia' by further notices of the two species—natroborocalcite and silicoborocalcite, now better known under Dana's names of *Ulexite* and *Howlite.*** Both minerals have been found good substitutes for borax in welding.

We learn from the 'Levant Herald' that a large meteorite fell at Mourzouk, in Fezzan, on or about the 25th December, 1869. The fall occasioned considerable consternation to a group of Arabs who were standing near, and they immediately discharged their muskets on the unwelcome stranger.††

It seems likely that the Australian mineral lately introduced under the name of Wollongongite will in future be known by some more appropriate designation. The Rev. W. B. Clarke has pointed out that some little error has arisen in assigning to this species a local habitation and a name. In fact, the so-called Wollongongite occurs not in Illawarra, but at a place called Petrolia, formerly known as Reedy Creek, where it was recognized by Count Strzelecki as far back as 1839. Under these circumstances the name ceases to be appropriate, so that "there can be no question, I think," says Mr. Clarke, "that Wollongongite is a misnomer, and that Professor Silliman will change it."

A good deal of common sense characterizes the little minera-

* 'Jahrbuch f. Mineralogie,' 1870, p. 196. † Ibid., p. 229.
‡ 'Sitzber. d. Kais. Acad. d. Wiss., 1869. No. XXV.
§ 'Corr. Blatt. d. z. Mineralog.' V. in Regensburg, 1870. p. 64.
‖ 'Chemical News,' May 13, 1870, p. 228. ¶ 'Geolog. Mag.,' 1870, p. 192.
** 'Phil. Mag.,' April, 1870, p. 275. †† 'Nature,' vol. i., p. 538.

logical guide which Dr. A. M. Thomson has published in Sydney,* for the assistance of explorers seeking to develop the mineral resources of the colony. Plain directions are given for easily recognizing the more important species—a task at all times extremely embarrassing to the unassisted beginner.

10. MINING AND METALLURGY.

Mining.

The newly drafted Bill amalgamating the Mines Regulation Bill and the Metalliferous Mines Bill has been printed. We cannot but think that this amalgamation will be found to be unfortunate. Nearly all the conditions of a coal mine and a copper or tin mine are so different, that it is quite impossible to apply the same legislation to them with any hope of advantage. This is shown on the face of the Bill itself. It now comprehends *three sets* of General Rules: one applicable to all mines; the second, to coal mines only; and the third, to mines other than coal mines. The redrafted Bill is supposed to embody the suggestions of the representatives of all the interests affected—it is therefore probably now in that form which will become law. In the last Quarterly Journal we sufficiently entered upon the principles of the Mines Regulation Bill, and therefore we need not occupy valuable space by enlarging upon its clauses.

Tin mining has, once again, resumed its condition of high prosperity in our western counties; the prices of tin ore (black tin), which have varied during the past quarter from 75*l.* to 85*l.* the ton, being such as to leave a large profit to the miner. The result of this is that numerous new tin mines are being opened, and the miners have full employment and are getting good wages.

Copper mining is not in the same favourable condition. The Clifford Amalgamated Mines, which employed a short time since upwards of a thousand persons, are about to be abandoned, after a long and profitable career. These mines—which comprehend the United Mines, the Gwennap Consolidated Mines and Wheal Clifford —were the most extensive copper mines in this country. The levels were upwards of sixty miles in length, and from six to seven miles of shafts had been sunk upon the lodes. This mine was remarkable for the very high temperature of its lower levels. The miners in some of the ends of the levels worked in temperatures varying from 110° F. to 115° F., the water rising in those levels being at the temperature of 120 F. This hot spring was remark-

* 'Guide to Mineral Explorers in distinguishing Minerals, Ores, and Gems.' By Alexander M. Thomson, D.Sc. Sydney, 1869.

able for the great quantity of lithium which it held in solution. All the lower parts of the mine are now filled with water; a little tin is being obtained from the shallow levels; the machinery is being removed; and soon this scene of activity will become a silent ruin.

At Wheal Owles, in the mining district of St. Just, there have lately been discovered some valuable samples of the oxide of uranium, which have been sent into the market and realized high prices.

The Gold-fields of Nova Scotia.—The declared returns of gold for the whole province to the end of the year 1869 are as follows:—

Year.	Yield of Gold.	Number of Miners daily employed.	Quartz crushed.	Average yield per ton.	Annual earnings per man.
	oz. dwt. gr.	No.	cwts.	oz. dwt. gr.	$ c.
1862 ..	7,275 0 0	500	134,800	1 3 2	291 00
1863 ..	14,001 14 17	877	310,035	0 18 10	319 30
1864 ..	20,022 18 13	810	428,700	1 0 20	494 36
1865 ..	25,454 4 8	683	500,025	1 3 6	745 76
1866 ..	25,204 13 2	679	635,387	0 17 13	742 56
1867 ..	27,314 11 11	702	666,429	0 19 10	778 66
1868 ..	20,541 6 10	774	678,817	0 14 6	530 84
1869 ..	17,868 10 19	676	708,486	0 11 5	528 64
Total ..	157,682 9 8	713	4,092,679	0 15 10	553 90

The gross yield of gold in Nova Scotia during the past ten years has been 180,000 oz., representing, in round numbers, a value of 720,000*l.* sterling.

The produce of gold in Nova Scotia for the year ending 31st December, 1869, in all the gold-producing districts, is shown in the following Table:-

District.	Total yield of Gold.	Daily average of miners employed.	Quartz crushed.	Average yield per ton.	Value of average yield of Gold per man employed at $18·5 per oz.
	oz. dwt. gr.	No.	tons. cwt.	oz. dwt. gr.	£ *s.* *d.*
Stormont ..	227 0 13	19	784 0	0 5 19	47 15 11
Wine Harbour	719 8 19	65	2,726 12	0 5 6	44 5 6
Sherbrooke ..	5,546 11 16	134	11,500 0	0 9 15	165 11 6
Tangier	1,192 3 10	51	1,332 2	0 17 21	93 5 6
Montague ..	805 13 14	29	572 7	1 8 3	111 2 7
Waverley ..	1,591 14 10	54	3,915 15	0 8 3	117 18 1
Oldham	1,394 16 0	56	1,735 2	0 16 1	99 12 7
Renfrew	3,097 15 7	112	7,258 9	0 8 12	110 12 9
Uniacke	1,867 3 12	71	3,171 13	0 11 18	105 3 10
Lawrencetown .	30 0 20	20	223 0	0 2 16	6 1 8
Musquodoboit .	1,001 0 23	36	1,582 17	0 12 17	111 4 7
Unproclaimed districts ..	394 11 19	29	622 9	0 6 23	54 8 7
	17,868 0 19	676	35,424 6	0 10 2	105 14 7

The produce of gold for the month of February, 1870, being according to the Mineral Inspector's Report, as follows:—

District.	Gold yield.			Quartz crushed (Colonial weight).
	oz.	dwt.	gr.	tons.
Sherbrooke ..	309	0	0	694·03
Tangier	135	7	20	88·00
Oldham	104	7	14	200·07
Waverley ..	78	7	0	141·00
Renfrew	71	2	0	223·10
Musquodoboit	52	5	21	73·10
Uniacke	47	2	4	105·00
Wine Harbour	28	7	12	100·10
Isaac's Harbour	2	11	15	3·10

Mr. R. Brough Smith reports that the total quantity of gold raised in Victoria in 1869 was 1,544,757½ ounces, and of this there were exported 1,340,838½ ounces. The total imports into England of Australasian gold in 1869 were of the value of 7,892,757*l.* Since 1858 the imports have been as follows:—

	£.		£.
1858	9,064,763	1864	2,656,971
1859	8,624,566	1865	5,051,170
1860	6,719,000	1866	6,836,674
1861	6,331,225	1867	5,801,207
1862	6,704,753	1868	6,989,594
1863	5,995,368		

The increased returns of the last three years were due to the opening of new gold-fields in Queensland, South Australia, and New Zealand.

Metallurgy.

Mr. Spence, of Newton Heath, Manchester, has patented a new process of separating copper from ores. He takes the solution of chloride of copper as now obtained in extracting copper from ores (by the wet process) which contains iron in variable proportions, and generally contains free hydrochloric acid. This solution he places in large open vats, and in another vessel of cast iron, fitted with a revolving stirrer, he places a considerable quantity of the vat waste of the alkali manufacture, or the spent lime from the gas purifiers, and to this is added a solution of sulphate of ammonia, or chloride of ammonium. The vessel or still being closed, a jet of steam of from 20 to 30 lbs. pressure is blown into the mixture. Sulphide of ammonium distils over, and is conveyed by a pipe into the vat containing the metallic solution of copper and iron, by which sulphide of copper is precipitated, and the ammonia combines with the

liberated hydrochloric acid. The process is continued until all the copper is thrown down, which point is at once observed by sulphuretted hydrogen being evolved, when the process is stopped; for if continued, the ammonia would now neutralize the free acid, and the iron would then be precipitated. The sulphide of copper thus obtained is very nearly pure; it is washed and dried, and smelted into copper by any of the usual methods employed.

A new process of calcining tin and other ores has been adopted by Messrs. Oxland, F.C.S., and John Hocking. The ores are introduced into a revolving iron cylinder, 4 feet in diameter and 30 feet long, lined with fire bricks, and supported at an inclination of about $\frac{3}{4}$ inch per foot on three pairs of rollers, on which it is kept constantly revolving at a slow rate. The fire passes from the fire-place over a chamber into and through the tube. The ore having been first dried on iron plates in suitable flues, at the back of the calciner, is admitted in a steady stream into the higher end of the cylinder, and the slow revolving motion imparted to it causes the advance of the ore by its own gravitation, and it is discharged in a continuous stream into a chamber between the fire-place and the front of the tube. Great economy of fuel is said to be effected by this furnace. The heat from the fuel has to traverse more than double the distance over which it passes in Brunton's calciner before it escapes into the flues, and the tube presents nearly double the amount of heating surface. None of the working parts are exposed to the action of the fire. In working it is found to be economical both as regards fuel and labour.

Several patents have been taken out of late relating to the manufacture of iron and steel. Mr. Cowper, of Westminster, patents improvements in treating cast iron for the production of wrought iron and steel therefrom. By this process the purification of the cast iron is accomplished by a jet of superheated steam applied to a stream of the liquid iron as it flows from the blast furnace, so as to divide it up into small particles, and act upon them; the iron is received into a hot box, and transferred to a calcining furnace, in which it is kept hot whilst still exposed to an atmosphere of hot steam; such purified iron is mixed either hot or cold with liquid cast iron, and afterwards used as cast iron, or made into steel or wrought iron.

In the manufacture of steel Mr. Julius Baur, of New York, patents a process of alloying or combining metallic chromium with metallic iron, so that chromium in a metallic state shall be present in the finished product, which is said to impart valuable properties to it. This process is distinguishable from that secured by Mr. Robert Mushett for mixing oxide of chromium in the manufacture of steel.

Letters patent have also been granted to Mr. J. M. Stanley, of Sheffield, for improved modes of utilizing the heat given off during

the decarbonizing or converting process, the object of which is to economize the consumption of fuel, and reduce the cost of the metals.

There is also an invention whereby very superior iron and steel are said to be obtained by smelting titanic iron ore, Ilmenite, in a blast furnace, without the addition of any other metalliferous body; the alloy of iron thus obtained possesses a large percentage of carbon. Various methods are adopted to carry out this process. The inventor is Mr. T. S. Webb, of the Norton Iron Works.

11. PHYSICS.

LIGHT.—Spectrum analysis has been applied by Vogelsang and Geissler to the difficult question of determining the chemical nature of the fluid found enclosed, in minute quantity, in the cavities of certain quartz-crystals. Fragments of quartz were placed in a small retort, which was connected with an air-pump and exhausted; then, by the application of heat, the quartz decrepitated, and the evolved vapour was examined in a Geissler-tube. The presence of carbonic acid was thus abundantly proved, and this was confirmed by the turbidity which it produced in lime-water.

A great improvement in the spectroscope has been made by Mr. Browning, who calls his instrument the automatic spectroscope. It is furnished with a battery of six equilateral prisms of dense flint glass; all the prisms are joined together like a chain by their respective corners, the bases being in this manner linked together. This chain of prisms is then bent round so as to form a circle with the apices outwards; the centre of the base of each prism is attached to a radial rod. All these rods pass through a common centre. The prism nearest the collimator, *i. e.* the first prism of the train, is a fixture. The movement of the other prisms is then in the proportion of 1, 2, 3, 4, and 5, the last or 6th prism moving five times the amount of the second. All these motions are communicated by the revolution of the micrometer screw, which is used for measuring the position of the lines in the spectrum; and the amount of motion of each, and of the telescope, is so arranged that the prisms are automatically adjusted to the minimum angle of deviation for the ray under examination. It is easy to test the efficiency of the instrument in this respect. On taking the lens out of the eye-piece of the telescope, the whole field of view is found to be filled with the light of the colour of that portion of the spectrum which the observer wishes to examine; while in a spectroscope of the usual construction, at the extreme ends of the spectrum, just where the light is most required, only a lens-shaped line of light would be

found in the field of view. As a consequence of this peculiarity, the violet and deep-red ends of the spectrum are greatly elongated, or rather, much more of them can be seen than in an ordinary spectroscope, and the H lines, which are generally seen only with difficulty, come out in a marked manner.

Drs. Roscoe and Thorpe have recently communicated to the Royal Society the results of a series of determinations of the chemical intensity of total daylight, made in the autumn of 1867, on the flat plateau of the river Tagus, about 8½ miles south-east of Lisbon, under a cloudless sky, with the object of ascertaining the relation existing between the solar altitude and the chemical intensity of the light. The experiments were made as follows:—1. The chemical action of total daylight was observed in the ordinary manner; 2. The chemical action of the diffused daylight was then observed, by throwing on to the exposed paper the shadow of a small, blackened, brass ball, placed at such a distance that its apparent diameter, seen from the position of the paper, was slightly larger than that of the sun's disk; 3. Observation No. 1 repeated; 4. Observation No. 2 repeated. Next, the means of observations 1 to 4 were taken. The sun's altitude was determined by a sextant and artificial horizon. One of the sets of 134 observations was made as nearly as possible every hour. It has been already pointed out, and proved by experiments made at Kew, that the mean chemical intensity of total daylight, for the hours equidistant from noon, is constant. The results of the present series of experiments prove that this conclusion holds good generally. One of the chief results arrived at is that, although the chemical intensity for the same altitude, at different places and at different times of the year, varies according to the varying transparency of the atmosphere, yet the relation, at the same place, between altitude and intensity, is always represented by a straight line.

A new and very ingenious graduating diaphragm for the microscope has been contrived by Mr. J. Zentmayer. This exceedingly ingenious arrangement is shown in the accompanying cuts, which are taken from photographs; Fig. 1 showing the apparatus with

Fig. 1.

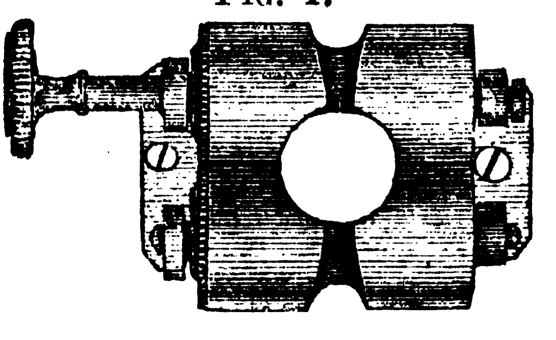
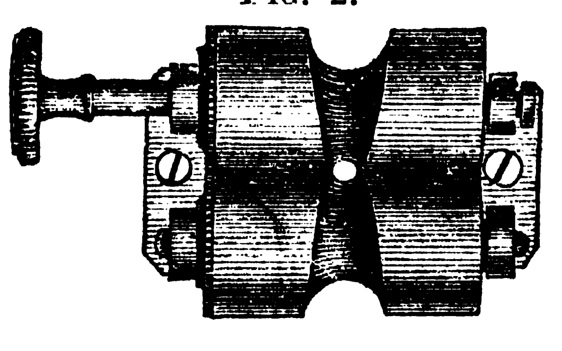


Fig. 2.



its largest, and Fig. 2 with its smallest opening. To obtain a circular diaphragm which, like the eye, should expand and contract

gradually by a continuous change, and yet be made of rigid and unchangeable material, might seem at first sight to be an impossibility; but, after all, when the result is accomplished, as in this apparatus, we are surprised as much by the simplicity as by the ingenuity of the means employed. The woodcuts almost explain the apparatus of themselves; but we may say, in addition, that it consists of two cylinders or rollers with parallel axes and surfaces in contact, having similar conical grooves on their surfaces, and fine teeth cut at one end of each, which, gearing together, cause them to rotate in unison. There is, theoretically, an objection to a diaphragm of this construction, from the fact that its opening will not always be in the same plane—that is, the smallest cross-section of the space between the rollers will not always be equidistant from a plane at right angles to the line of sight and passing through the axes of the rollers. With the larger opening, this cross-section will be nearest to, and with the smaller, farther from, such a plane. In practice, however, this difference is so small as to be entirely unimportant, and may even, in some cases, be turned to advantage.

Experiments have been made at Toulon by M. F. Silvas to try to attach to life-buoys another floating body provided with phosphide of calcium, which, on becoming wet, gives off spontaneously combustible phosphuretted hydrogen, thus emitting light to guide the man, who might have fallen overboard and be in search of the life-buoy.

HEAT.—Dr. Guy has arranged in series the different poisonous substances according to their melting and sublimation temperatures. The arrangement is as follows:—(1) Sublimates formed without any previous change of state of aggregation, and giving white vapours; under this head are brought bichloride of mercury, calomel, arsenious acid, and cantharidine. (2) Sublimates after previous fusion, and without leaving any residue—*viz.* oxalic acid. (3) Sublimates after previous fusion, leaving a carbonaceous residue—morphine and strychnine. (4) Fusion, change of colour, sublimation and deposition of carbonaceous residue, aconitine, atropine, delphine, veratrine, brucine, digitaline, picrotoxine, solanine. (5) Decrepitation; slow and partial sublimation; tartar emetic.

Professor Morren has instituted some experiments on the combustibility of diamonds, and the effect of a high temperature on these gems. The author, in a letter, first relates the following facts as having given rise to his experiments. A jeweller at Marseilles was requested to enamel afresh the gold bearings of two large diamonds of great value, used as shirt buttons. Instead of taking off the diamonds, always a delicate operation, the jeweller, who had frequently executed such work previously, decided to enamel the gold while the diamonds were left on their bearings. Not having

charcoal at hand, the jeweller took coal for heating the muffle for enamelling, an operation which succeeded most perfectly; but on taking the buttons from the muffle, the jewels had become perfectly black, and no amount of rubbing or friction restored them to their pristine state. The jeweller was therefore obliged to dismount the jewels, which looked like plumbago, and to send them to Paris, when by the first touch of the lapidary's wheel they became restored to their former beauty; while, curiously enough, their weight had not changed. Professor Morren who, through the kindness of MM. Laurin, jewellers at Marseilles, was enabled to experiment with several diamonds, placed them on a small platinum boat in a platinum tube, and tried the effect of a high temperature simultaneously with different gases. Heated in coal-gas the gems become blackish, increase in weight, and are found to be coated with a strongly-adhesive layer of carbon, such as is deposited in gas retorts; in pure hydrogen, the gems may be heated almost to the melting-point of platinum without undergoing any change; heated in carbonic acid gas, the gems become dull and lose a little weight. The carbonic acid gas was found to be dissociated into carbonic oxide and carbonic acid; this, the author found, was caused by the platinum and not by the diamond. When the diamond is placed in oxygen gas and ignited, it continues to burn, but remains white, appearing as a piece of unpolished glass; the stone does not blacken, nor swell up, and, if it is free from flaws or cracks, does not split asunder.

Dr. Janssen, who, it will be remembered, went to India for the purpose of observing the total solar eclipse, has communicated some observations on the artificial production of ice in India. In many parts of the Indian continent, the natives dig shallow pits in localities which are freely open to the sky and distant from trees. The pits are lined with straw, and upon the straw are placed dishes (made of a very porous earthenware) filled with water. During the calm and clear nights prevailing in the period from November to the end of February the water placed in the dishes freezes, yielding a solid cake of ice, while the temperature of the air is $+ 10°$. Dr. Janssen has investigated this curious subject experimentally, and has found that the freezing is principally due to the radiation during the night; but the evaporation of the water, aided by the porosity of the earthenware employed, is at the same time not to be overlooked.

In order to exhibit the effect of the expansion of water when freezing, F. Rüdorff fills with distilled and previously well-boiled and cooled water a cast-iron cylinder, having the following dimensions:—Height, 160 millimètres; diameter (external), 50 millimètres; thickness of solid iron, 15 millimètres. After having been filled with water this apparatus is closed by means of a plug screwed into the neck, and the cylinder is next placed in a mixture of three parts

of snow or pounded ice, and one part of common salt; after about forty minutes the cylinder bursts with a loud report. It is essential for the success of this experiment that the plug fits very perfectly, and that the cylinder, after having been filled with water, be placed for some time in ice. The wooden pail which contains the freezing mixture should be roomy, and be covered with a stout towel to prevent the spirting about of the contents at the time of the bursting.

Some experiments on the freezing of wine have been tried by A. Rousselle. The reason why freezing improves wines, under certain conditions, is, according to this author, because by partial freezing the proportion of all the fixed substances in the liquid wine is increased; and these are, moreover, thereby rendered more fit for causing the combination of the acids with the alcohol, so as to form those ethers to which wine owes its peculiarly distinct flavour, aroma, and strength.

Dr. Hann has tried to solve by observation the problem of the decrease of the temperature of the air in relation to the elevation above sea-level, by comparing the average of temperature as observed at certain groups of stations situated under the same mean latitude and longitude, and by taking into account local influences. Seven of these groups are situated in the western portion of the Alps, at from 230 to 3330 mètres above sea-level; four in the northern part of Switzerland, at from 500 to 1780 mètres above sea-level; three in the Rauhe Alps (Wurtemburg), at from 310 to 810 mètres above sea-level; four in the Erzgebirge (Central Germany), at from 180 to 850 mètres above sea-level; and four in the Harz (province of Hanover and Brunswick), at from 70 to 1140 mètres above sea-level. The results obtained have proved that, in the instances mentioned, the decrease of the temperature of the atmosphere near the ground is really proportionate to the height of the locality above sea-level. When the results of all the observations are duly considered, there is discovered a strongly marked annual periodicity, and a very uniform decrease of temperature from below to above, the average relation of the temperature reigning in December being, to that of June, as 1 to 2.

Dr. Von Wartha has obtained solid disulphide of carbon by the rapid evaporation of this liquid itself, in the same way as solid carbonic acid is formed. The solid sulphide melts at 9° F., and has the appearance of small cauliflowers.

Some time ago M. Lamy proposed a pyrometer based upon the dissociation of carbonate of lime. He now proposes to apply ammoniacal chloride of calcium, which gives off ammonia at low temperatures. The instrument is to be connected with a manometer, which will record the temperature. The contrivance is to be especially adapted to record the temperature at different depths under the

surface of the soil. In reference to this, M. E. Becquerel and others have very properly observed that better and far more accurate means for accomplishing this purpose exist already, and are daily employed with success.

A valuable substance for crucibles and fire-bricks has recently been discovered. There occurs, in the Département des Ardennes, France, a variety of hydrated silica known by the name of gaize, and geologically situated below the cretaceous deposit; the thickness of this layer is 30 mètres, and it extends over a distance of 24·85 English miles. The sp. gr. of this substance is 1·48 in crude state, and after ignition 1·44. This stone is used as a building stone; it is, at first, quite soft, so that it can be cut with a knife. The material resists a very high temperature without fusion or cracking, or, also, of perceptible contraction, either cubical or linear, and it has consequently been recommended for the manufacture of crucibles (on the lathe), for fire-bricks, and for furnaces.

Electricity.—A cause of error in electroscopic experiments has been pointed out by Sir Charles Wheatstone, F.R.S. In the course of some experiments on electrical conduction and induction the author was frequently delayed by what at first appeared to be very puzzling results. Occasionally he found that he could not discharge the electrometer with the finger (or only to a certain degree), and that it was necessary, before commencing another experiment, to be in communication with a gas-pipe which entered the room. How he became charged could not at that time be explained; observation and experiment, however, soon led Sir Charles to the true solution. He was sitting at a table not far from the fire-place, with the electrometer (one of Peltier's construction) before him, and was engaged in experimenting with discs of various substances. To ensure that the one in hand (which was of tortoiseshell) should be perfectly dry, it was held for a minute before the fire. Returning, and placing it on the plate of the electrometer, it had apparently acquired a strong charge, deflecting the index of the electrometer beyond 90°, and it was then observed that the same thing took place with every disc thus presented to the fire, whether of metal or any other substance. The first impression was that the disc had been rendered electrical by heat; but, on placing it in contact with a vessel of boiling water, or heating it by a gas-lamp, no such effect was produced. The next conjecture was that the phenomenon might arise from a difference in the electrical state of the air in the room, and that at the top of the chimney. That this conjecture, however, was not tenable was soon evident, because the same deviation of the needle of the electrometer was produced by bringing the disc near any part of the wall of the room. This seemed to indicate that different parts of the room were in different electrical states; but this, again, was dis-

2 G 2

proved by finding that, when the positions of the electrometer and the place where the disc was supposed to be charged were interchanged, the charge of the electrometer was still always negative. The last resource was to assume that the author himself had become charged by walking across the carpeted room, though the effect was produced even by the most careful treading. This ultimately proved to be the case; for, resuming his seat at the table, and scraping the foot on the rug, Sir Charles was able, at will, to move the index to its greatest extent.

As a substitute for copper for the Daniell Electric Battery, Dr. C. Stölzel proposes to take a piece of well-polished tin plate (sheet tin, not tinned iron), immerse it in a very dilute solution of a copper salt, and put it in connection with a weak galvanic current. After the lapse of from fifteen to eighteen hours a layer of strongly adhering metallic copper will have become firmly deposited upon the tin plate; and the latter, after having been bent into the required shape, is an excellent, cheap, and durable substitute for the copper cylinder in Daniell's battery.

Considering the numerous experiments now being tried on wine, it is to be hoped that the quality of the cheaper kinds of this beverage will shortly show some improvement. Whilst Dr. Rousselle proposes to freeze wine, Dr. Scontettin prefers to electrify it. As a very tangible proof of the gain obtained by the immediate conversion of young wines into drinkable beverages by means of electricity, the author states that, considering that the annual production of wine of France amounts to from 60 to 70 millions of hectolitres (each equal to rather more than 22 gallons), and that at least 10 francs per hectolitre is lost by vaporization during the time of the maturity of the wine while in casks, this represents an amount of from 600 to 700 millions of francs gained by rendering wine fit for immediate consumption by the author's electric process. We may not inaptly apply here, "Si non e vero e bene trovato."

Some useful electrolytic experiments have been tried by P. Burckhard. After describing his arrangement, the author states that oxide of bismuth is not a conductor of electricity unless it be in a state of fusion, but in that case one of the copper electrodes becomes coated with bismuth; while, if platinum electrodes are used, there is formed at one of the electrodes a very fusible alloy of the two metals. Fused borax is not a bad conductor, although the author confirmed the statement made by Dr. Tichanowitsch that pure boric acid does not conduct electricity at all. When borax in a fused state is experimented with, a series of compounds are formed or volatilized; but the main result is its decomposition into soda, oxygen, and boron. Pyrophosphate of soda in a fused state yields, among the products of electrolysis, phosphide of platinum,

if a platinum electrode be applied; but the decomposition, which is chiefly the result of the electrolysis of this salt, is its splitting up into oxygen, phosphorus, and soda. Carbonate of soda in a fused state is a good conductor of electricity; it is decomposed into carbonic acid and soda, but a small portion of carbon is also formed.

A series of very accurate experiments, made with chemically pure substances, have been tried by M. E. Becquerel, on the electromotive force of divers substances, as for instance, pure carbon, gold, platinum, &c., in the presence of water and other fluids. Among the curious facts elicited is this, that pure gold, obtained from the French Mint, is acted upon by pure water in a manner not hitherto explained, but which gives the author occasion to ask whether possibly gold does not contain another substance which has not been discovered, or whether perhaps the slow action of the water is not the cause of the disaggregation of the gold, thus explaining the fact of its being found in rivers in the state of dust.

In a very lengthy paper on the properties of galvanically-precipitated iron, R. Lenz records a series of experiments, not only made with iron, but also with copper. The results are stated as follows:—Iron and copper, when reduced to the metallic state by electricity, contain gases occluded, among which hydrogen is in largest amount: the bulk of gas thus occluded varies considerably, but iron has been found by the author to occlude as much as 185 times its own bulk. The absorption of the gases is more considerable in the first layers of metal deposited. On being heated, the iron loses gas, even below 100°, the gas evolved at so low a temperature being chiefly hydrogen. Iron which has been galvanically precipitated, and then made red-hot and cooled, becomes oxidized when put into water, that liquid being decomposed and hydrogen given off.

12. ZOOLOGY—ANIMAL MORPHOLOGY AND PHYSIOLOGY.

Morphology.

A new Ganoid Fish from Australia.—We have this quarter to record what is certainly the most important zoological acquisition which science has received since the finding of the Archæopteryx of Solenhofen. Mr. Gerard Kreft, the able curator of the Australian Museum of Sydney, who has already by his single exertions shown us what a rich mine of new forms is still waiting to be brought to the hands of science in the Australian continent, has sent over photographs of a fish obtained in the rivers of Eastern Queens-

land, which has at first sight very much the aspect of the African *Protopterus* or South American *Lepidosiren*. The Queensland fish is, however, larger than Lepidosiren, measuring nearly 5 feet in length. A further examination of the photographs sent by Mr. Kreft shows that the fins, which are long worm-like appendages in Lepidosiren, with a very slight border of fin-rays, are here much more developed, being broader and flat, with a large axial lobe and diverging rays, something like those of *Polypterus*. The scales are large and solid-looking—to judge by the picture—and with a wave-like sculpture on the surface, recalling the palæozoic Holoptychius in this respect, as well as in the long-lobed fin. The photographs of the skull display a most formidable array of long, wedge-shaped teeth, with undulating edges, exceedingly like those of the Carboniferous Ceratodus. The teeth are, in their limited number and position, very similar to those of Lepidosiren, but have even a more marked resemblance to Ceratodus than have the latter. Mr. Kreft was so struck with the resemblance to Ceratodus that he has proposed to call this marvellous fish, which he places with amphibians, *Ceratodus Forsteri*, after the gentleman who discovered it. The name *Potamothauma* has, however, been also proposed, since we have no right to relegate it to an extinct genus solely on the ground of agreement in the teeth. It is impossible to exaggerate the importance of this discovery with reference to the problems of the geographical distribution of organisms, and the ancient relations of land and water. On the other hand, this fish has an equal interest from the purely zoological point of view. We believe that specimens are not very difficult to obtain, so that some may soon be expected in this country. How is it that no one has yet studied the development of Lepidosiren? Surely, now that in three-quarters of the globe such a fish has been found, the eggs and fry may be expected to be made known. It is only quite recently that the development of Polypterus—the Ganoid of the Nile—has been studied on the banks of its habitation, and the fact that it commences life with large external gills like those of a young Newt, or of a very young Tadpole, clearly established.

The Graphic Method in Odontology.—The study of teeth, not from the dentist's but from the naturalist's point of view, is of very great importance, since by the power of drawing correct inferences from a few teeth we are able to arrive at most weighty conclusions as to the age of Tertiary and other strata. The study of teeth, particularly of mammalian teeth, has become quite a speciality—a little field of knowledge requiring great care and perception of form for its successful cultivation, and standing apart from other anatomical work. So great is the amount of attention required in this study, and so great the importance attached to it, that the late Dr. Falconer occupied most of his life with the study of the teeth oı Elephas, Mastodon, and Rhinoceros; whilst a fellow of the Royal

Society has been raised to that dignity because he had confined his studies to the molar series of Rhinoceros and Hyæna. Anything which will simplify this study and reduce it to the level accessible to ordinary minds must therefore be hailed with pleasure, and the method which Mr. George Busk has devised is exceedingly valuable in that way. Mr. Busk proposes to convert *number* into *form* in the case of teeth, for increase of twentieths of an inch in breadth using extension of a line, just as the mathematician proceeds in drawing a curve representing progressive phenomena. The paper ruled in fine squares of a tenth of an inch or so, which physiologists and others make use of in recording rises of temperature or increase of movement at successive intervals, is employed by Mr. Busk. To obtain the odontogram of any mammal, you mark off as many horizontal lines as there are teeth in the molar series; let each division on the horizontal lines made by the perpendicular represent, say a tenth of an inch; then with compasses measure the breadth of your first molar, mark it with a dot on the first horizontal line in tenths of an inch; then measure the second and mark it on the second line, and so on for all seven—if seven there be. Your dots will now be at various distances from the perpendicular zero line, according to the breadth of each tooth: join the adjacent dots and you have an irregular figure produced of *definite* form and *characteristic of the species.* On the same set of lines you can now measure out the lengths, or antero-posterior dimensions of the same teeth, and produce a figure overlapping your first figure, equally characteristic, the two together giving an exceedingly accurate and trustworthy means of comparing the dental series in allied species. With regard to the teeth of some of the large pachyderms Mr. Busk has proposed certain points of measurement besides those of length and breadth, which we may hope soon to see adopted. It would be an inestimable boon to palæontologists if Mr. Busk would found a system of measurements for all mammalian teeth, and publish at the same time an authoritative series of such measurements with odontograms of all the known recent and fossil mammalia. It at any rate might be done with Rhinoceros and the Carnivora to begin with.

The Zoological Position of Sponges.—It is not three years since in chronicling the discussions to which the glass-rope sponge, *Hyalonema*, gave rise, we had to mention that Ehrenberg the great microscopist—who still is in Berlin outliving his age—holds to his old belief that Sponges are Vegetals. We have now to record that Professor Ernst Haeckel, of Jena, proposes to associate the Sponges with the Corals and Hydromedusæ, bringing them under the group Cœlenterata. Haeckel has attacked in former years that heterogeneous assemblage which we still know as the Protozoa; and he removed from it the Infusoria proper, leaving the Sponges, the Radiolarians, the Amœboids, the Foraminifera, the Gregarines, and

the Monera (a group of simplest forms which he himself discovered) associated with the Flagellata and Diatomaceæ as Protista. Haeckel now proposes—with very great propriety, we think—to remove the Sponges from this company, with which they have no close relation at all, their complex aggregated structure finding no parallel in any of the other groups, and the fact that they are built up of amœboid and ciliate cells in large measure, being absolutely as true for all animals as for Sponges. Two years since in the Canaries, Haeckel was with his pupil, Miklucho-Maclay, and there the latter paid particular attention to the calcareous Sponges, and both he and Haeckel were much struck with the high degree of organization which these forms presented. Haeckel has since studied the calcareous Sponges (which are represented by the genus Grantia on our coasts) in the Adriatic; has found an immense number of new forms, and has watched the development of a great number. He now points out that the central orifice, or "osculum," of such a sponge as *Grantia* is homologous with the mouth of Cœlenterata; that the canals of the Sponge too are homologous with the canal-system of Corals, though they open externally by the temporary pores in the former. He describes a small form, *Prosycum*, which has not canals opening thus, but only the central orifice, and this he considers very near to the common ancestor of the Sponges and Nematophora (Corals, Hydræ, Ctenophora), which he distinguishes as *Protascus.* Haeckel can distinctly demonstrate an endoderm and ectoderm in many Sponges, whilst in some of the Calcispongiæ we have the presence of those radiating septa or "antimera" so characteristic of Corals. The Calcispongiæ make the nearest approach to Nematophora by the distinctness of the "persons" which they present, each osculum, or mouth, and canal-system stands alone, like a separate polyp. In other Sponges there is much fusion and merging of persons into a common individuality—in various ways which Haeckel explains—one of these consisting in the possession of a single osculum by several persons. Professor Haeckel's proposal has already been attacked in England by Mr. Kent, of the British Museum, who thinks that the osculum of a sponge cannot be the homologue of the mouth of a sea-anemone, because the water runs in at the latter but out at the former—really no reason at all as far as homology is concerned. He also thinks Cœlenterata differ from Sponges in having. free-will, which Sponges have not, and declares the Sponges to be the head of the Protozoa.

Spermatophores in Fresh-water Annelids.—In the last number of the 'Quarterly Journal of Microscopical Science,' Mr. Ray Lankester announces the discovery of these structures in the genera *Nais*, *Tubifex*, *Limnodrilus*, and *Clitellis*. Peculiar elongate bodies fringed with slowly-moving cilia, and occurring in the seminal receptacles of *Clitellis* and *Limnodrilus*, had been described under

the name *Pachydermon* by M. Claparède as parasites, similar to the well-known *Opalinæ.* Mr. Lankester having detected these bodies in a new species of *Limnodrilus* living in ponds at Hampstead, carefully examined their structure, and found that they were simply closely-fitted masses of spermatozoa, held together by a viscid cement, and with their tails projecting beyond this viscid matter freely, and thus giving the appearance of ciliation. Further, Mr. Lankester had observed exceedingly long coiling bodies in the seminal receptacles of *Nais*, and he had no doubt from their structure that these also were spermatophores. This curious phenomenon of the aggregation of the spermatozoa into definitely-shaped masses after their complete development and separation from their developmental aggregation, has been observed in Molluscs, Insects, and Marine Annelids, but not hitherto in the Oligochœta. It is not easy to conjecture what purpose may be served in the worm's economy by this strange aggregation of the spermatozoa. The appearance presented by the masses is very like that of a densely-ciliated Infusorian, and they move gracefully along the stage of the microscope as though endowed with an individual vitality, instead of being but a spirally-interwoven mass of sexual particles. The same number of the Journal contains an important paper by Professor Cleland "On the Structure of the Grey Matter of the Brain," and one by Dr. Van Beneden "On *Nematobothrium.*"

Surface Life of the Ocean.—Lieutenant Ingram Palmer, having a considerable talent for drawing, determined to investigate the various minute forms of life which abound on the ocean surface. He arranged a series of nets for towing behind the vessel to which he was attached; purchased a small microscope, and set to work to examine everything and draw everything which came to hand. The result is, a very large collection of beautifully-executed drawings of minute crustacean larvæ, worms, Pteropodous Molluscs, Echinoderm larvæ, and various adult Amphipods and Isopods of great beauty, few being larger naturally than a pin's head. The amount of work and skill represented by these drawings is something enormous, and yet they will probably prove of no scientific value. They have been exhibited at the Geographical and Linnæan Societies, and are now in a magnificent frame at the Admiralty. The talented and persevering artist who produced them had absolutely no knowledge of what he was drawing, and did not go to work with the critical power of a zoologist, and hence he has drawn much that was well known before, and has often failed to give the details required for zoological purposes, though his drawings are exceedingly clear and accurate. A very little previous education in Natural History—the opportunity for which ought to be given to every officer in Her Majesty's service—would have rendered Lieutenant Palmer's great talents available for science. It is to be hoped that the Admiralty

will now grant him the time to study, so that when he again finds himself afloat he may be able to do that service in zoological science which his perseverance and artistic skill would ensure.

Physiology.

The Moving Force of a Single Cilium.—An interesting experiment has been recently made by Dr. Jeffreys Wyman, of Cambridge, Mass., and repeated by Dr. Bowditch, of Boston, now in Professor Ludwig's laboratory at Leipzig, which suggests to us the above heading. If the ciliated membrane from the palate and fauces of the common frog be carefully removed and stretched on a perfectly smooth plate whilst quite fresh and moist, and on this surface a weight be placed, its surface being carefully covered with a piece of fresh peritoneum of the frog to prevent the contact of dead matter with the cilia, it will be found that the weight is slowly moved along by the force of the cilia, a weight of as much as four grammes being actually transported in this way—slowly but perceptibly. Dr. Bowditch has varied the experiment by cutting off the head of a frog and inserting a glass tube into the mouth, so that the ciliated surface may work on the rod, and he has actually succeeded in causing the head to move along the rod when in a horizontal position or but very slightly inclined against the direction of movement, simply by the ciliary power. It would be interesting to know the mechanical equivalent of a single cilium; that is to say, what fraction of a horse-power, for instance, a cilium power may be.

The Movements of Wings in Flight.—It is to Dr. J. Bell Pettigrew, F.R.S., of Edinburgh, that the credit is due of first advancing the view that during flight the movement of wings is such as to describe a figure of eight if progression of the whole body be hindered. In an elaborate investigation into the mechanism of flight in various animals, insects, birds and bats, he demonstrated that the structure was such as to provide for and necessitate this form of movement; in fact, the wing should act as a reciprocating screw. Whilst acknowledging that Dr. Pettigrew has the merit of first giving this account of the movements of flight, Dr. Marey, of Paris, the illustrious physiologist, who has so successfully applied the graphic method to the study of the circulation and of muscular contraction, has demonstrated the truth of Dr. Pettigrew's inference from structure by actual experiment. An insect's wing being gilded and a strong beam of light used, its movement could be followed by the eye; also by allowing it to brush against a cylinder covered with lamp-black, the figure of its movement was obtained. Dr. Marey is now investigating by most ingenious methods the flight of birds—with a view to determine exactly what is the effective part

of the stroke in the movement of the wing. The movement of the wing itself is recorded by an arrangement with an electric current, wires being connected with a small instrument carried on the bird's back. The impulse upwards or forwards is also recorded by means of an elastic bag containing air, on the surface of which lies a piece of lead: when a sudden movement occurs at right angles to the plane of the lead plate, it compresses the air in the bag by its inertia, and this movement is recorded by means of a tube, another bag and a lever, as in the cardiograph.

Peregrinations of Cells in the Living Body.—The study of living tissues to which Cohnheim's views on inflammation (*viz.* that there is no multiplication of the cells of connective tissue, but that pus cells are extravasated white blood corpuscles) have given rise, progresses very rapidly in Germany under the hands of Von Recklinghausen of Wurzburg, of Stricker of Vienna, of Rollet of Gratz, and their pupils. It appears certain now that both white and red blood corpuscles do freely pass through the capillary walls in inflammation; but it is equally certain, from the admirable researches of Stricker, that cells multiply in inflammation which are *not* white blood cells, such as the stellate cells of the cornea, the corneal epithelium, the connective-tissue cells of the tongue, and others which Stricker has seen under his eyes commence and finish the act of division. Among the most remarkable results recently obtained from this study of living cells is the observation of Saviotti, that cells pass *into* the capillaries and small veins as well as *out of* them. He has seen this frequently occur with the pigment cells of the frog's web, when inflammation was set up by dilute sulphuric acid, and the fact was recently witnessed also in the laboratory of Professor Stricker, of Vienna. The pigment-cells deliberately advance to the capillary wall, and passing through it are carried along in the circulation. These facts as to living cells are so remarkable that some have been inclined to suppose there is optical illusion. They are, however, now placed beyond doubt by repeated observation. Movements of cells in the tissues may now be demonstrated in many parts as well as the cornea, in the frog's egg of the second day, in the brain, in the fœtal liver, in the skin (migrated cells of Besiadecki); and hence Kölliker's supposition that all cells at one time or other can exhibit active movement is likely to be established. Recklinghausen has kept an excised frog's cornea alive for six weeks by supplying it with fresh serum and attending to cleanliness; a wonderful proof of independent vitality.

Physiology in Trinity College, Cambridge.—Trinity has lately proved her claim to stand alone and at the head of the colleges in Cambridge by the establishment of a prælectorship in pure physiology, to which that able teacher, Dr. Michael Foster, of University College, London, and Fullerian Professor in the Royal Institution, has

been called. It is a peculiar source of gratification to Dr. Foster's friends that he is able to accept this chair, since at the beginning of the year family bereavements and the threatening of serious illness held out but a gloomy prospect for future work. Dr. Foster is now in good health and will enter on his duties at Cambridge in October. When we remember that on former occasions as well as quite recently, Trinity has expressed her willingness to make some of her collegiate property available for the endowment of Professorships in the University in natural sciences, and that her generous intentions have been baulked by the ignorant parsimony of certain of the smaller colleges, we cannot but congratulate her upon having taken this step. It goes far to confirm the enumeration of Universities once given by a Trinity man, *viz.* "Dublin, Oxford, Cambridge, and Trinity College." We hope the college will provide Dr. Foster with a *large* laboratory.

Laboratories in Amsterdam and London.—Professor Kuhne has recently delivered an admirable discourse on the importance of physiological research on the occasion of the opening of the grand physiological laboratory which the city of Amsterdam has built for him. This laboratory and that of Professor Ludwig at Leipzig are the most perfect in Europe, though there are many others coming near to them. Ludwig's laboratory is as extensive as the whole of the Cambridge and Oxford laboratories taken together. There is not even one physiological laboratory in England, though we may hope to see one, at University College, as a memorial to Dr. Sharpey. King's College recently refused to build one, though Dr. Beale offered to assist in the expense in a most generous way. A strong attempt is being made to get something in the form of a laboratory put up at the public expense through the Privy Council. Let us be thankful for any such movement.

Quarterly List of Publications received for Review.*

1. Researches on Diamagnetism and Magne-crystallic Action; including the question of Diamagnetic Polarity. By John Tyndall, LL.D., F.R.S., &c. *Longmans, Green, & Co.*
2. Notes of a Course of Nine Lectures on Light, delivered at the Royal Institution of Great Britain. By John Tyndall, LL.D., F.R.S. *Longmans, Green, & Co.*
3. Other Worlds than Ours: the Plurality of Worlds studied under the light of recent scientific researches. *With Illustrations.* By Richard A. Proctor, F.R.A.S. *Longmans, Green, & Co.*
4. Alpine Flowers for English Gardens. By Wm. Robinson, F.L.S. *With Illustrations.* *John Murray.*
5. Forms of Animal Life, being Outlines of Zoological Classification based upon Anatomical Investigation, and Illustrated by Descriptions of Specimens and of Figures. By George Rolleston, D.M., F.R.S., &c. *Oxford: Clarendon Press.*
6. Strong Drink and Tobacco Smoke: the Structure, Growth, and Uses of Malt, Hops, Yeast, and Tobacco. *With* 167 *original Illustrations, drawn and engraved on Steel.* By Henry P. Prescott, F.L.S. *Macmillan & Co.*
7. A Handbook of Phrenology. By C. Donovan, Ph.D., &c. *With Illustrations.* *Longmans, Green, & Co.*
8. Contributions to the Theory of Natural Selection. A Series of Essays by Alfred Russel Wallace, F.R.G.S., &c. *Macmillan & Co.*
9. The Ornithosauria: an Elementary Study of the Bones of Pterodactyles, made from Fossil Remains found in the Cambridge Upper Greensand. By Harry Govier Seeley. *With* 12 *Plates.* *Cambridge: Deighton, Bell, & Co. London: Bell & Daldy.*
10. A Manual of Zoology for the Use of Students; with a General Introduction to the Principles of Zoology. By Henry Alleyne Nicholson, M.D., D.Sc., &c. Vol. I.: Invertebrate Animals. *R. Hardwicke.*
11. L'Uomo e la Natura. Ossia la Superficie terrestre Modificata per Opera dell Uomo. Di Giorgio P. Marsh. *Firenze: G. Barbera.*

*** We cannot undertake to acknowledge books and pamphlets on purely theological subjects, nor such as concern betting transactions.**

12. Burton-on-Trent; its History, its Water, and its Breweries. By William Molyneux, F.A.S. *Trübner & Co.*
13. The Fuel of the Sun. By W. Matthieu Williams, F.C.S. *Simpkin, Marshall, & Co.*
14. Burton and its Bitter Beer. By J. S. Bushnan, M.D. *William S. Orr & Co.*
15. A Star Atlas for the Library, the School, and the Observatory, &c. *With Two Index Plates with Coloured Constellation Figures.* Drawn by Richard A. Proctor, B.A., F.R.A.S., &c., &c. *Longmans & Co.*
16. On the Manufacture of Beet-root Sugar in England and Ireland. By William Crookes, F.R.S., &c. *Longmans & Co.*

PAMPHLETS AND PERIODICALS.

On the Thermal Resistance of Liquids. By Fredk. Guthrie.

On Ocean Currents. By James Croll.

Records of the Geological Survey of India.

Notes of Fifteen Lectures (to Women) on Physics. Delivered by Professor Guthrie at South Kensington Museum.

Descriptive Catalogue of One Hundred Microscopic Objects. Exhibited at the Royal Microscopical Society by C. Stewart, F.L.S.

Notes on Diatomaceæ. By Professor A. M. Edwards. (Boston, U.S.A., Natural History Society.)

Report presented to the Minister for Agriculture, &c., respecting the Vaccinations performed in France in 1865 and 1867. Translated by George S. Gibbs.

Report on the Present State and Condition of Pre-historic Remains in the Channel Islands. By Lieut. S. P. Oliver, R.A., &c.

What Shall we Teach? or, Physiology in Schools. By Edwin Lankester, M.D., F.R.S. *Groombridge & Sons.*

Biographical Sketch of the late Fredk. Penny, Ph.D., &c., Glasgow. By James Adam, M.D.

The Currency Question. By Rigby Wason.

Report on the Agriculture of Belgium. By Dr. Augustus Voelcker and H. M. Jenkins, F.G.S. (Reporter).

An Irish Farmer on the Land Difficulty. By J. E. Scriven.

On the Relative Safety of the Different Methods of Working Coal. By Mr. George Fowler.

Stanford's Geological Map of London.

A Guide to the Study of Insects. By A. S. Packard, jun., M.D. *Salem, Mass. London: Trübner & Co.*

Notes on a Trip to the Nicobar and Andaman Islands. By V. Ball. (Bengal Asiatic Society.)

Life and the Equivalence of Force. By J. Drysdale, M.D.
London: Turner, 77, Fleet Street. Liverpool: Holden.

Announcement of the Forthcoming Series of Annual International Exhibitions. *Science and Art Dept.*

The Gardener's Magazine.

Journal of Applied Chemistry. *New York, &c.*

The American Naturalist. *Salem, Mass.*

The Canadian Naturalist, and Proceedings of the Natural History Society of Montreal. *Montreal: Dawson Bros.*

Revue Bibliographique Universelle.

The Geological Magazine. *Trübner.*

The Food Journal. *Johns & Sons, Castle Court, Holborn.*

The Popular Science Review. *R. Hardwicke.*

Scientific Opinion. 75, *Great Queen Street, London.*

The Westminster Review. *Trübner.*

Fraser's Magazine. *Longmans.*

Longmans' Notes on Books.

Williams and Norgate's Foreign Book Circular.

PROCEEDINGS OF LEARNED SOCIETIES, &c.

Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar.
Stockholm: Norstedt & Söner.

The Thirty-seventh Annual Report of the Royal Cornwall Polytechnic Society. 1869.

Proceedings and Transactions of the Nova Scotian Institute of Halifax, Nova Scotia. *London: Reeves & Turner,* 196, *Strand.*

First Annual Report of the American Museum of Natural History.
New York.

The Journal of the Historical and Archæological Association of Ireland. *Dublin: McGlashan.*

Transactions of the Geological Society, Glasgow.

Proceedings of the Bath Natural History Society and Antiquarian Field Club. *Bath: Chronicle Office.*

Proceedings of the Royal Institution of Great Britain.

" " Royal Society.

" " Royal Astronomical Society.

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JOURNAL OF SCIENCE.

OCTOBER, 1870.

I. THE ECLIPSE OF AUGUST 7, 1869.—"ANVIL" PROTUBERANCE.

By W. S. Gilman, jun., New York.

Those who observed the solar eclipse of last August with a sizeable telescope will not soon forget the startling effect produced by the appearance of the large oval protuberance on the western limb of the moon. We were unusually favoured as to atmosphere at our station near Sioux City, Iowa, and when in addition to this it is stated that our observations were made by the aid of a 4-inch refractor—one of Mr. Alvan Clark's best—it will not seem strange that the details about to be recorded were so readily obtained.

The "anvil" protuberance, for such the object is recorded in my notes, was seen by one of our party several moments prior to the totality.

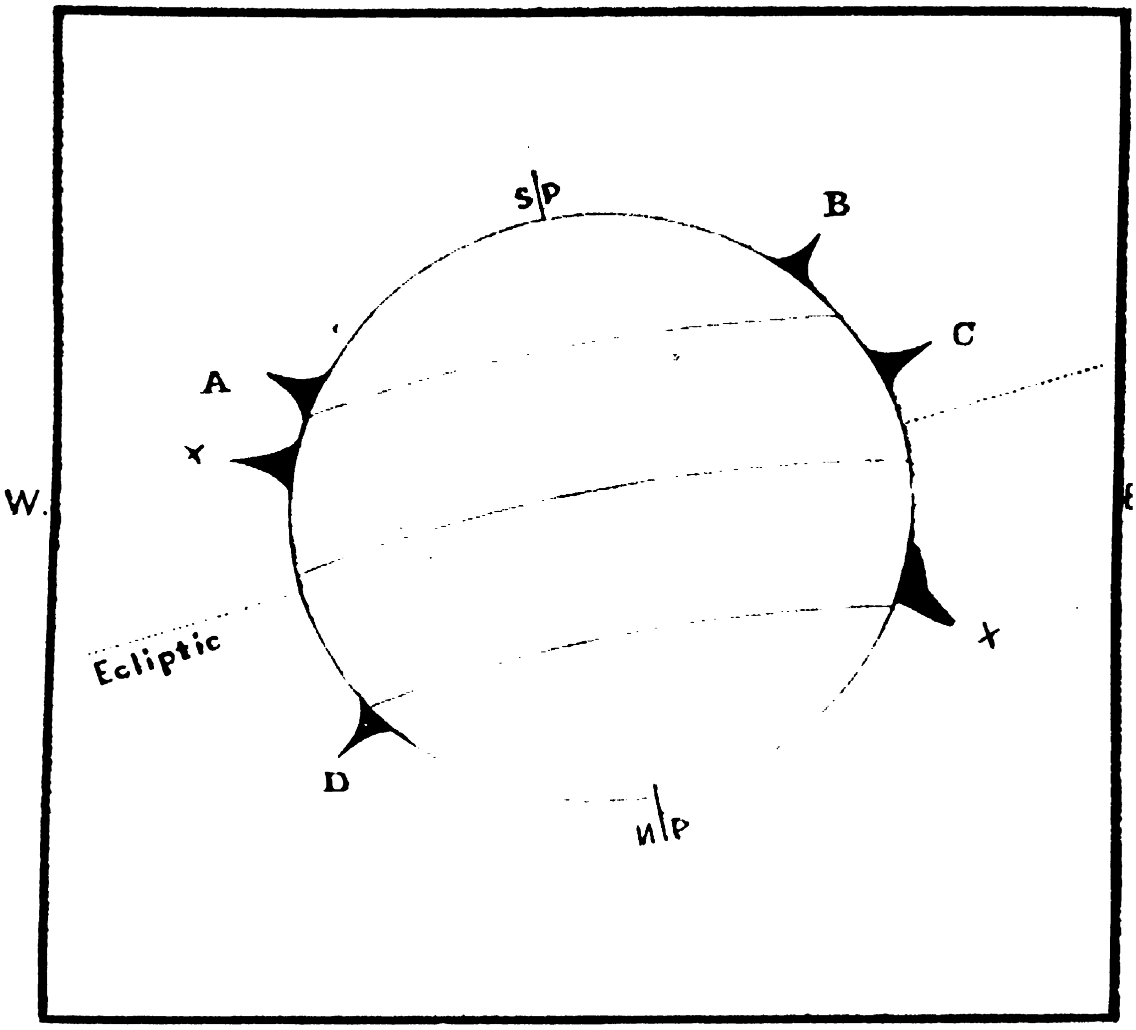
Several months' study of the sun's surface had prepared me to expect the more remarkable protuberances in the southern hemisphere, and having selected the south-western quadrant as an especially favourable locality, from the presence of faculous ridges near the limb two days prior to the eclipse, the bright "anvil"-shaped mass instantly attracted my attention. Its extraordinary brilliancy enabled me afterwards to keep it in view when a considerable crescent of the reappearing sun had rendered the corona invisible.

A hasty glance at other portions of the moon's limb satisfied me that the "anvil" protuberance possessed greater interest than any other, and I therefore devoted my whole time to its consideration, except so much as was employed in obtaining several outline sketches of the corona.

In a forecast of the probable positions of protuberances, which I made on August 5 (see Fig. 1), the double prominence at A occupies very nearly the position of the object under discussion. In Fig. 2 we have the appearance of the sun's disc on the same day, and near that part of the limb subsequently occupied by the "anvil," we notice a cluster of bright faculous spots. It was the

FIG. 1.

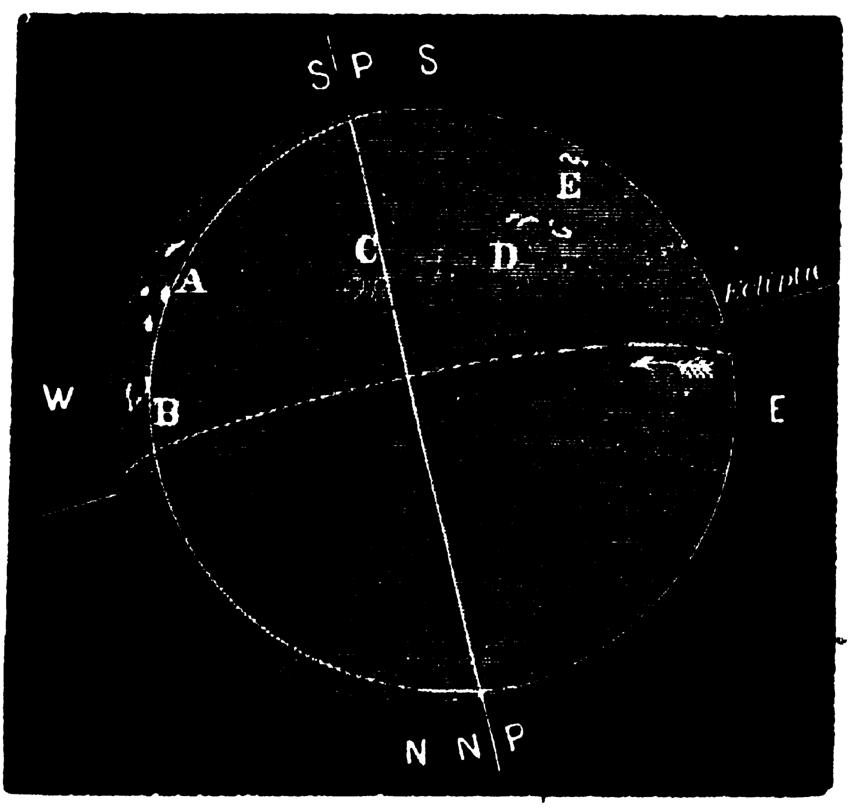
S.



N.

ROSE PROTUBERANCES AS FORECASTED
AUGUST 5, 1869.

FIG. 2.

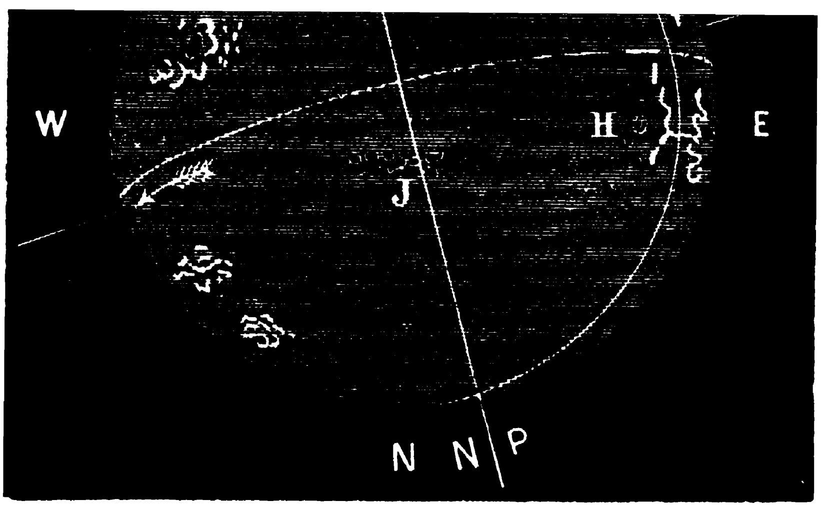


Solar disc, August 5, 1869.

intense whiteness of these objects that led me to suppose there might be hovering above the solar surface in this region gaseous exhalations that would appear during the eclipse. The white meridian in this second diagram represents the limb of the sun for the 7th of August, and it will be noticed that the cluster of faculæ is just beyond this line. A similar white meridian in the diagram giving the appearance of the sun on the 9th of August (Fig. 3), indicates the eastern limb of the sun during the eclipse.

FIG. 3.

FIG. 4.



Solar disc, August 9, 1869.

In this latter instance we have the faculous ridges marked I, G, F, E, which may be referred to prominences 4, 5, 6, and 7 of Prof. Mayer's diagram. It is worthy of special notice that the faculous masses at I are very irregularly disposed, the tortuous windings of its parts suggesting whirling motions in the photosphere. Prof. Mayer's "Eagle" prominence is a fit object to hover over such a curiously-agitated portion of the solar surface. That my sketch gives a correct representation of the windings of these ridges of faculæ I feel quite confident. While making the observation the outline was likened to a rude drawing of a camel (Fig. 4). The resemblance may appear to some if the page is inverted, the camel being supposed to face to the left.

Fig. 5 is a copy of my sketch of the spots on the sun's disc, as they appeared an hour previous to the eclipse. There was little or no change in their form or position until after the close of the phenomenon. The large spot near the eastern limb, enveloped in a platform of faculæ, is the same as that visible on the 9th (Fig. 3) near the same locality.

I was particularly impressed with the *stability* of the protuberance. It resembled a monstrous *white-hot coal*, and its outline

Fig. 5.

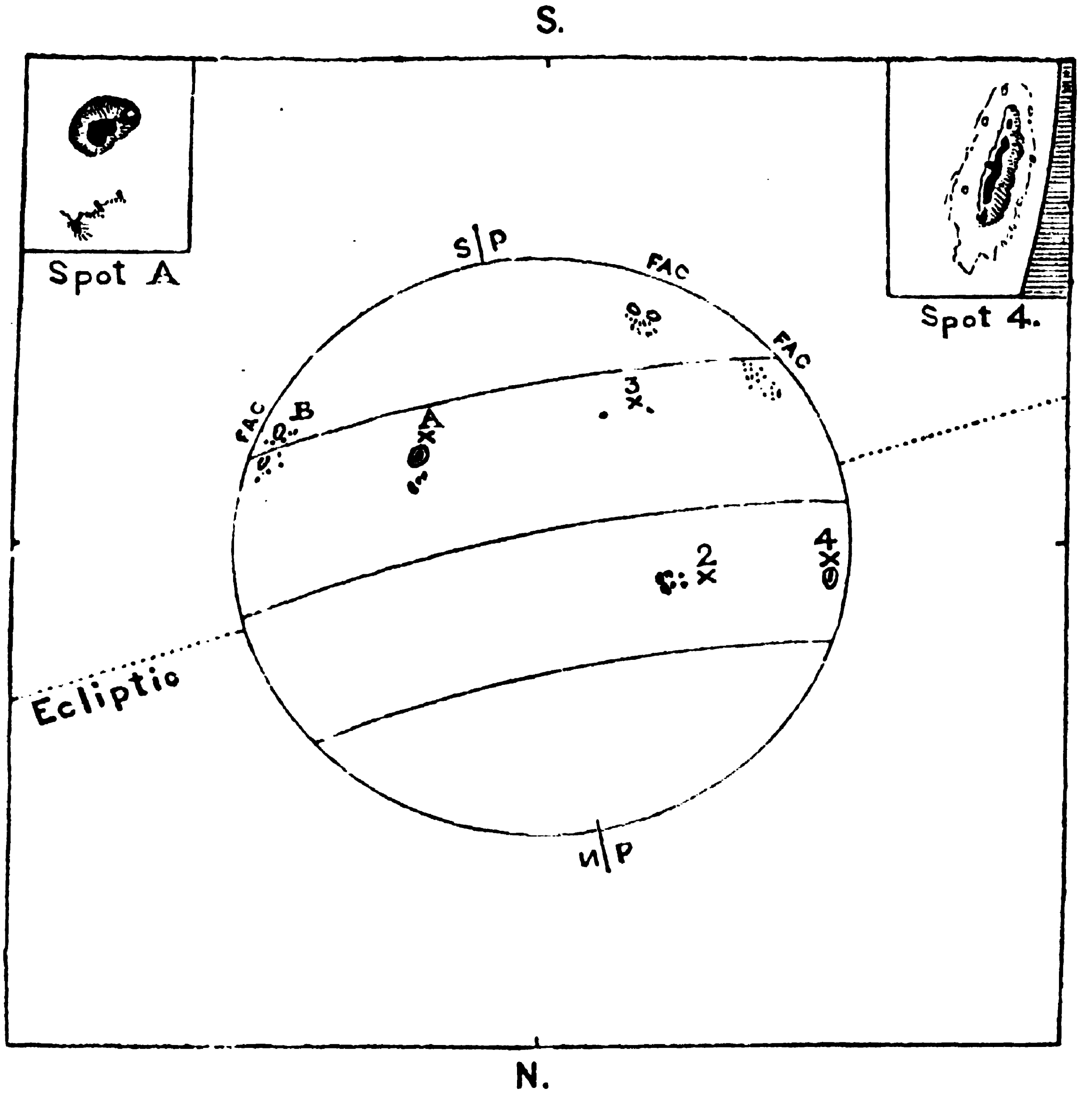
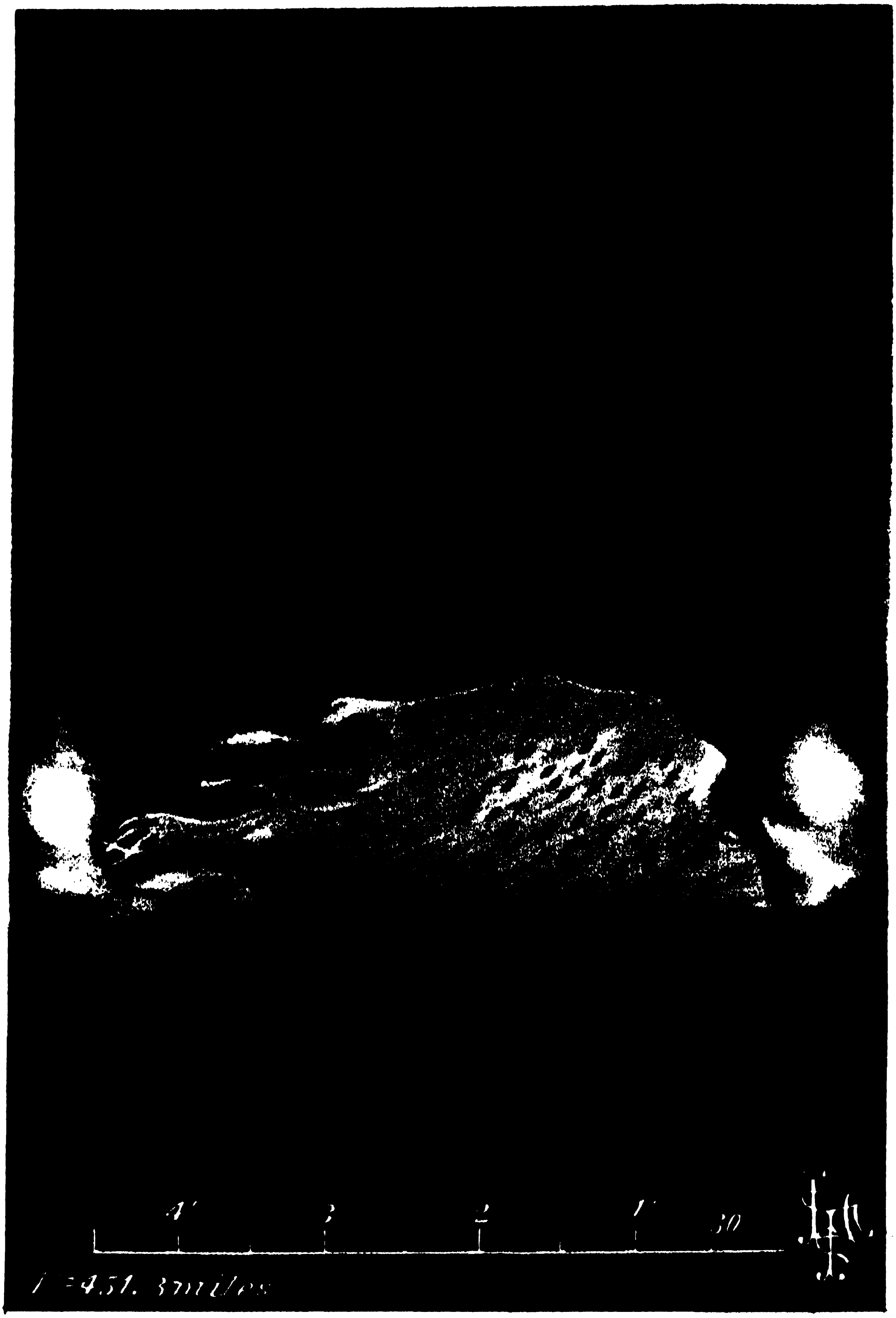


DIAGRAM SHOWING SPOTS ON THE SUN DURING THE ECLIPSE, AS SKETCHED ONE HOUR PREVIOUS TO THE FIRST CONTACT.

was sharp and well defined. The appellation "*rosy* protuberance" struck me at the time as a misnomer. I detected only bright *fire-orange* tints, like the glowing coals of an anthracite grate, with delicate crimson flakes of surprising brilliancy scattered over the southern part.

These flakes stood out against the bright background as if totally disconnected from the rest of the phenomenon. In the plate I have endeavoured to give their positions and the direction of their axes, which latter coincided with the stratification of the protuberance. I should estimate the length of these brilliant dashes of crimson light at from 3″ to 5″. Possibly in a future eclipse a momentary spectrum of them may be obtained, as their extraordinary brilliancy may make amends for their minute size.

The plate accompanying this article was prepared from my observations of the great protuberance, with the exception of the outline of the mass, which was obtained from the last Ottumwa



THE "ANVIL" PROTUBERANCE

OF THE TOTAL ECLIPSE OF AUG. 7 1869 FROM SKETCHES AND NOTES MADE DURING TOTALITY AT ST. PAUL JUNCN. IOWA.

OUTLINE TAKEN FROM THE PHOTOGRAPHS

photograph of the totality. In preparing this illustration the lithographer has been very successful in copying my sketch, the plate as given recalling the protuberance to my mind with great freshness and power. The flaky structure of the protuberance I have endeavoured to indicate by a deeper tint of orange running diagonally across the flame. The southern end is more compact than that turned towards the equator, which latter breaks up into several smaller independent clouds, between which, and suspended fully 10,000 miles above the solar surface, projects the tapering point of the "anvil." A casual glance at the sketch impresses one with the idea of a down-rush of the glowing matter from the southern end to the "anvil" point.

The details of the termination of this tapering end are wholly from my notes, which record that this part of the protuberance was composed of "fibrous lines of flame" apparently in motion and emitting a tremulous light. I have now a vivid recollection of the impressions produced upon my mind by this portion of the phenomenon which riveted my attention for some moments. In the photographs the tapering end of the protuberance terminates in a misty ball, which is what we should expect if the fine lines revealed by the telescope were really in motion.

One word regarding the *corona*. By a slight movement of my instrument its limits were brought into view, and its extent quickly indicated on diagrams previously prepared. At the same time I indicated by two heavy pencil-marks the positions of certain bands, or *intervals*, in the light of the corona on opposite sides of the moon's disc. These dark intervals deserve a passing notice.

In my coloured sketch of the corona, made immediately after the eclipse, and which accompanies my report published by the Washington Naval Observatory, I have indicated the positions and character of these bands. The absorption bands of the solar spectrum occurred to me at the time as an illustration of the delicate striations in these portions of the corona. In the case of one gap a multitude of fine violet lines were compressed into a space of about 10° in width, forming, to my mind, one of the most beautiful features of the eclipse. The same striated appearance was noticed in other regions of the corona, though in a less striking degree.

These apparent gaps in the corona's light I judged to be opposite elevated portions of the chromosphere, from the fact that there was a similar diminution of light above the great protuberance, as my sketches show. This point was not carefully examined, however, from want of time. On my return from the south, in February last, it occurred to me to compare my sketch of the corona with the diagram of protuberances accompanying Professor Mayer's report in the October number of the 'Journal of the

Franklin Institute,' published in Philadelphia. This I did, for the first time, on the 9th of that month, finding a fair agreement between the southern portions of his prominences 5 and 10, and the dark bands given in my sketch. I have, therefore, little doubt but that in locating these dark intervals in my original sketches, I intended to place the western one near 285°, and the eastern one near 120°, great exactness not being obtainable in the few moments given to the observation. In speaking of these bands as *dark*, I would be understood only as meaning that they were sufficiently so to be *readily seen.*

A comparison of the Des Moines and Ottumwa pictures of the "anvil" protuberance gives the following measurements. It will be noticed that the figures are somewhat in excess of those obtained from the last totality picture made at Burlington.

	"		Miles.
Extreme length of the "anvil"	265	or	119·800
" " base of the "anvil"	205	"	92·500
Greatest altitude above the sun's surface	81	"	36·500

Thus if, as is probable, the entire protuberance was not visible, its base being beyond the sun's limb, we have a bright cloud in the solar atmosphere nearly, if not quite, equal in volume to the planet Jupiter, and which in the direction of its length would suffice to reach more than half way to the Moon in her perigee.

THE SURVEYS OF INDIA.

II. THE TRIGONOMETRICAL SURVEY.

(With a Sketch-map.)

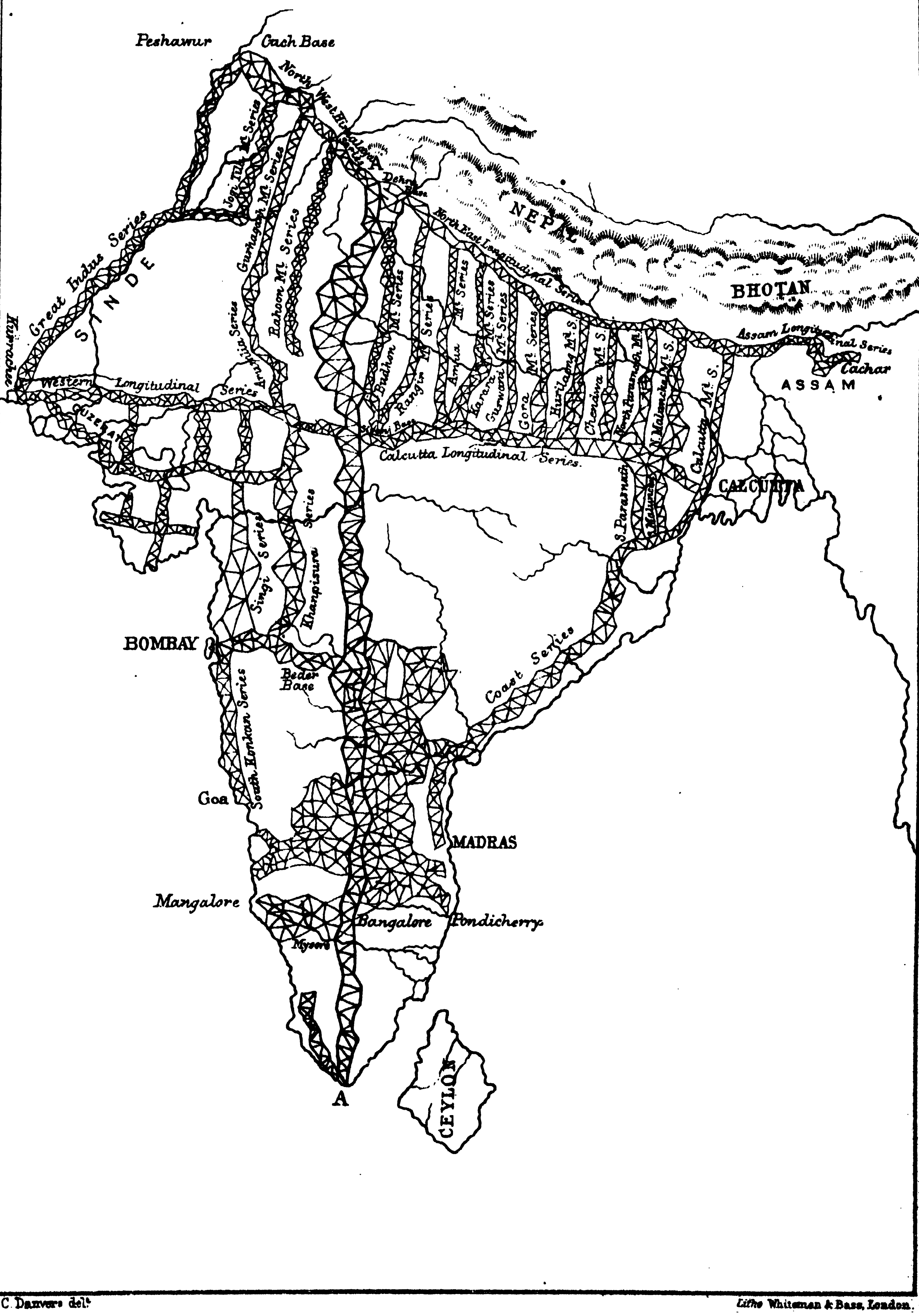
By F. C. Danvers, A.I.C.E.

The surveys of India may be divided into two classes—*viz.* the Great Trigonometrical, and the Geological. In connection with the former, other minor operations are undertaken under the title of topographical and revenue surveys, to which we shall refer more particularly in due course.

The idea of a great trigonometrical survey of a country, to be undertaken by the Government of that country, was first conceived by General Watson, at the suppression of the rising in Scotland in 1745. The execution of it was committed to General Ray, and was originally intended to extend no farther than the disaffected districts of the Highlands. The design, however, was subsequently enlarged, and the grand trigonometrical survey of Great Britain

OUTLINE MAP OF INDIA
shewing the Principal Triangulation Series of the
GREAT TRIGONOMETRICAL SURVEY.

A.A. *The Great Arc Series* —



F. C. Danvers del.

Lith. Whiteman & Bass, London.

and Ireland was projected. Perhaps a more important survey, in some respects, than the British one was that undertaken by the French nation at the period of the Revolution. About that date the philosophers of France undertook to introduce a great reformation in regard to all those habits and usages of men which have reference to numbers, and everything—lengths, areas, moneys, weights, periods of time, arcs of circles—was to be numbered by tens, hundreds, thousands, &c. The question then came to be, What should be adopted as the basis of this standard, which was designed not only for France, but for the world? This question having been brought to the attention of the Constituent Assembly, it was proposed by M. de Talleyrand, and decreed accordingly, that the Parliament of England should be requested to concur with the National Assembly in fixing a natural unit of weights and measures; that under the auspices of the two nations, an equal number of Commissioners from the Academy of Sciences and the Royal Society of London might unite in order to determine the length of the pendulum which vibrates seconds in the latitude of 45° (as proposed originally by Huyghens), or in any other latitude that might be thought preferable, and to deduce from them an invariable standard of measures and of weights. The Commission named by the Academy had under their consideration three different units, namely, the length of the pendulum, the quadrant of the meridian, and the quadrant of the equator. The length of a quadrant of the meridian having been determined on, the measurement of an arc was entrusted to MM. Mechain and De Lambre, who began their labours in 1792, and thus commenced the trigonometrical survey of France.

The origin of the Great Trigonometrical Survey of India was not unlike that of the first Scottish Survey. After the successful termination of the war with Tippoo Saib, at the close of the last century, Captain Lambton (who had previously served as a surveyor in America, and who joined Her Majesty's 33rd Regiment at Calcutta in the year 1797) brought forward his plan of a geographical survey of part of the territory that had been conquered, and he proposed to throw a series of triangles across from Madras to the opposite coast, for the purpose of determining the breadth of the peninsula in that latitude, and of fixing the latitudes and longitudes of a great many important places, which were believed to be very erroneously determined in the survey previously executed by Colonel MacKenzie. Captain Lambton first submitted his plan to Colonel Wellesley, in whose regiment he had formerly served, who at once sent up the proposal to Government supported by his strong recommendation. Lord Clive was at that time Governor of Madras, and warmly approved of the undertaking, and it was accordingly sanctioned by Government.

The first base line measured by Colonel Lambton was on the table-land of Mysore, near to Bangalore. The chain used by him was one of blistered steel, constructed by Ramsden, and precisely similar in every respect to the one used by General Roy in measuring his base of verification on Rumney Marsh. It consisted of forty links of $2\frac{1}{2}$ feet each, measuring in the whole 100 feet, at a temperature of 62°, and fitted with two brass register-heads, with a scale of 6 inches to each. This chain, it appears, had originally been sent with Lord Macartney's embassy as a present to the Emperor of China, and having been refused by him, it was made over by his Lordship to the astronomer, Dr. Dinwiddie, from whom it was purchased. The measurement of this base line was commenced on the 14th October, 1800, and completed on the 10th December following. Its total length was 7·4321 miles.

Whilst these operations were being carried on, an order was on its way to England for a supply of instruments of the best manufacture that could be obtained. Amongst these was a new chain which Colonel Lambton never allowed to be taken to the field, but it was reserved as a test, whereby that actually used was constantly verified. The other instruments received from England were a 36-inch theodolite, by Cary; an 18-inch repeating theodolite by the same maker; a 5-feet zenith sector, by Ramsden; a standard brass scale, by Cary; and several small theodolites, by different makers, for minor purposes. These instruments were the finest that the state of art at the commencement of the present century could produce.

On the 10th April, 1802, the real commencement of the Great Trigonometrical Survey of India was made, although at that time the extent to which those operations would be ultimately carried was not even contemplated. Upon the resumption of operations no notice appears to have been taken of the Bangalore base line. Work was commenced by the measurement of a fresh base line of 40006·4 feet, on a plane near Saint Thomas' Mount, Madras, at no great distance from the shore, and nearly on the level of the sea. From this a series of triangles was carried, about 85 miles eastward, north as far as the parallel of 13° 19′ 49″ N., and south to Cuddalore, in latitude 11° 44′ 53″, embracing an extent of about 3700 square miles. Before describing further the progress of the survey, we must pause for a moment in order to give some account of the care taken in measuring the base line. The chain was in all respects similar to the one used at Bangalore. It was laid in coffers or long boxes, supported on stout pickets driven into the ground, and their heads dressed even by means of a telescope. At one end of the chain was a draw-post, to the head of which the near end of the chain being fastened, it could be moved a little backwards or forwards by means of a finger screw. Near the handle of the chain,

and at a point where its measuring length was supposed to commence, there was a brass scale, with divisions, which was fixed to the head of another picket, distinct both from the draw-post and from those supporting the coffers. This scale could, by means of a screw, be moved backwards and forwards on the head of the post till it coincided with the mark on the chain. A similar arrangement was made at the other end, but the handle of the chain, instead of being firmly attached to the weigh-post, as it was called, had a rope passing over a pulley; and to this rope was appended a weight of 28 lbs. to keep the chain stretched. This arrangement enabled the measurer to move his chain backwards or forwards with the greatest nicety, and when satisfied that it was correctly placed, to keep it there perfectly steady; while, by means of the registers, he marked the places of the two extremities of the chain. The chain was then lifted by twenty coolies and carried forward, the near end being adjusted to the scale which had before marked the fore end. A new chain's length was then laid off in a similar manner, and so on, until the base was finished. During these operations tents were erected over the line, and thermometers were placed in the coffers to determine the temperature of the chain; and the rate of expansion having been previously determined by experiment, the necessary corrections were made for the varying temperature of the measurement. The quantity of this correction was ·00725 inch for every degree of Fahrenheit.

Many of the triangles carried forward from this base line had sides of from 30 to 40 miles in length. In computing their length Colonel Lambton reduced the observed angles to the angles of the chords, according to the method of De Lambre; and though he computed the spherical excess, he did not use it in any other way than as a measure of the accuracy of his observations. The chords, which were the sides of the triangles, were then converted into arches; and as Colonel Lambton had contrived that the sides of the four triangles which connected the stations at the south and north extremities should lie very nearly in the direction of the meridian, their sum, with very little reduction, gave the length of the intercepted arch, which was thus found to be 95721·326 fathoms. By a series of observations for the latitude, at the extremities of this arch, made with a zenith sector, the amplitude of the arch was found to be 1°·53233, by which, dividing the length of the arch just mentioned, Colonel Lambton obtained 60494 fathoms for the degree of the meridian bisected by the parallel of 12° 32′. This, till the survey was extended farther to the south, was the degree nearest to the equator—excepting that in Peru, almost under it—which had yet been measured. The next object was to measure a degree perpendicular to the meridian, in the same latitude. This degree was accordingly derived from a distance of more than 55

miles, between the stations at Carangooly and Carnatighur, nearly due east and west of one another. Very accurate measures of the angles which that line made with the meridian at its extremities, were here required; and these were obtained by observations of the Polar star when at its greatest distance from the meridian. For this purpose a lamp was lighted, or blue lights were fired at a given station, the azimuth of which was found by the Polar star observations, and afterwards its bearing was taken in respect of the line in question. Thus the angle which the meridian of Carangooly makes at the pole with that of Carnatighur, or the difference of longitude of these two places, was computed. It was then easy to calculate the amplitude of the arch between them; and thence the degree perpendicular to the meridian at Carangooly was found to be 61061 fathoms. Upon comparing this degree of the perpendicular with the degree of the meridian, the compression at the poles would appear to be equal to $\frac{1}{210}$. A writer in the 'Philosophical Transactions' for 1812, p. 342, contended that, on account of an error in calculation which escaped Colonel Lambton, the foregoing measurement should be diminished by 200 fathoms, thus reducing the length of the degree of the perpendicular to 60861 fathoms, which would give $\frac{1}{330}$ for the compression. These measurements were made in 1803.

In May, 1804, a base of verification of 39793·7 feet (7·536 miles, reduced to mean sea-level) was measured by Lieutenant Warren, Colonel Lambton's assistant, near Bangalore; and though the distance was nearly 160 miles, the computed and measured lengths of this base differed only 3·7 inches, or about half an inch in the mile; a proof of the great care and accuracy with which the work was conducted. This base was adopted for the origin of the great Indian arc series, to which we shall presently refer more particularly. From it a series of triangles was carried across the peninsula to the Malabar coast, which they intersected at Mangalore on the north and Tellicherry on the south. The heights of the stations were all determined from the distances and observed angles of elevation. The most considerable heights were at Soobramanee and Taddiandamole, in the western ghauts, not very far from the coast, the former being 5583 feet, and the latter 5682 feet above the level of the sea; but notwithstanding having to cross such elevations, after carrying the survey over a distance of 360 miles, it was found that the sum of all the ascents, and of all the descents, reckoned from the level of the sea, differed from one another only by 8½ feet. From the triangles thus carried across the peninsula, a correct measurement of its breadth was obtained, and one considerably different from what was before supposed. The distance from Madras to the opposite coast, in the same parallel, was ascertained to be very nearly 360 miles; whereas, until then,

the best maps made it exceed 400 miles. All the principal places on the old maps, which had been fixed astronomically, were also found considerably out of position: for example, Arcot was out 10 miles, and Hydrabad no less than 11 minutes in latitude and 32 minutes in longitude.

For a long period the operations referred to above were frequently interrupted by the disturbed political condition of the country, which was often the scene of warlike operations; for it was not until the Marquis of Hastings destroyed the Pindaree confederacies in 1818 that the peninsula and Deccan settled down into quiet and repose. The mysterious character of the instruments and operations, as well as the planting of flags and signals, always more or less awakened the apprehensions or excited the jealousy of the native princes; and it required, therefore, no ordinary tact, firmness, and patience, in order to conciliate their good-will.

Between the years 1802 and 1815, a network of triangles was, under the superintendence of Colonel Lambton, carried over the whole country as high as 18° latitude, whereby the peninsula was completed from Goa on the west to Masulipatam on the east, with all the interior country from Cape Comorin to the southern boundaries of the Nizam's and Mahratta territories. Subsequent to this achievement, the great arc triangulation was extended nearly to Takal Khera, in latitude 21° 6′. The greater part of the Nizam's eastern territories were triangulated by meridional series between the Kistnah and Godavery, and considerable progress was made in the longitudinal series from the Beder base towards Bombay. The area comprised by the whole of the operations prosecuted during the time Colonel Lambton was superintendent aggregated 165,342 square miles. In October, 1817, the Marquis of Hastings, impressed with the important utility of the trigonometrical survey, resolved to transfer the control over its operations to the Supreme Government of India, which took effect from the 1st January, 1818, and Colonel (then Captain) Everest was appointed assistant to the superintendent, whom he subsequently succeeded upon the death of Colonel Lambton on the 20th January, 1823. Colonel Everest first acted as chief assistant during the latter part of 1818, and he was employed, in the first instance, in the triangulation of the eastern parts of the Nizam's dominions, and subsequently on a longitudinal series of the great triangles emanating from the Beder base line towards Bombay. He was engaged on this important work at the time of Colonel Lambton's death, by which event he succeeded to the office of superintendent, and immediately proceeded to concentrate the resources at his disposal on the extension of the great arc series, which, after many difficulties, was at length carried up to latitude 24°, where a base line was measured at Seronj.

After this, Colonel Everest proceeded to England, returning

thence, in 1830, provided with geodetical instruments and apparatus of every description executed by the most skilful artists of the day, including a complete base-line apparatus, the invention of Colonel Colby, precisely similar to that employed on the Ordnance Survey; a great theodolite, 36 inches in diameter; two 18-inch theodolites; and a variety of smaller instruments from 12 inches diameter downwards. The signals, all of the most efficient kind, and recently invented, consisted of heliotropes, reverberatory lamps, and Drummond's lights, of which the two former have been exclusively used.

In addition to the duties of Superintendent of the Trigonometrical Survey, Colonel Everest had, on his return to India, to perform those of Surveyor-General of India. In 1833 the offices of Deputy Surveyor-General at Madras and Bombay were abolished, and their duties devolved upon the Surveyor-General, so that Colonel Everest had now to perform the work which had hitherto occupied the undivided attention of four officers.

By the end of 1832 a longitudinal series of triangles had been completed from Seronj to Calcutta, where another base line was measured. Upon the completion of that work the measurement of the great arc was re-commenced, after a cessation of seven years. It was carried on from that time unremittingly till December, 1841, when the whole Indian arc from Cape Comorin to the Himalayas, forming the main axis of Indian geography, was finally completed. The area comprised by the great arc operations, principal and secondary, aggregated 56,997 square miles, including the revision of the section from Beder to Kalianpoor, and the measurement of three base lines, each from 7½ to 8 miles in length, *viz.* those of Beder, in latitude 18°; Seronj, near Kalianpoor station, in latitude 24°; and the Dehra base, about 70 miles north of Kaliana station, in latitude 29° 30′, where the great arc actually terminates; this distance being observed on account of the proximity of the Himalayas. On comparing the actual measurement of the Debra Dhoon base by Colley's apparatus with that calculated from the Seronj base, measured by the chain in 1824, a difference of nearly 3½ feet was found. In former times this would have been considered a very satisfactory agreement, seeing that the length of the base is 7½ miles, and its distance from the new base upwards of 400 miles in a straight line; but Colonel Everest considered the difference as indicating a much larger error than ought to exist, regard being had to the precision of the new methods. In order to set the question at rest, he resolved to re-measure the old base with the more complete apparatus he now had at his command. This operation was completed in January, 1838, when it appeared that the length given by the chain measurement of 1824 was too short by nearly 3 feet, as compared with the new result.

In the year 1829 a trigonometrical survey in the Bombay Presidency was commenced by Lieutenant Shortrede, on an independent base and point of departure. This survey proceeded in an unsystematic manner until it was brought under Colonel Everest's control in 1831, when, finding that no use could be made of this confused net of triangulation, the Colonel directed that the longitudinal series should be taken up where he left off in 1823. This was concluded in 1841, the series extending over a distance 315 miles in length.

The space at our disposal will not admit of a detailed account of the several series of triangulation carried out by the Trigonometrical Survey Department; they will, however, be seen by reference to the accompanying map. Besides the great arc series, extending from Cape Comorin to Dehra Dhoon, there are two longitudinal series, the one extending from Cachar, in Assam, to Peshawur, and the other from Calcutta to Kurrachee: between these are numerous series of triangles, those to the east of the great arc being at distances of about one degree, or 60 miles apart, taking meridional directions, thus forming what is called a gridiron system, similar to that adopted in the French and Russian surveys. Base lines are measured at the extremities of the longitudinal chains, and at the points where the chains cross Colonel Everest's arc; thus the triangulation is divisible into large quadrilateral figures, with a base line at each corner.

Colonel Everest was succeeded in the appointment of Superintendent of the Great Trigonometrical Survey and Surveyor-General of India by Captain (afterwards Sir) Andrew Waugh, in December, 1843, who held the combined offices for seventeen years. Sir Andrew Waugh left the service in 1861, when he was succeeded by Colonel J. T. Walker, R.E., as Superintendent of the Great Trigonometrical Survey, and by Colonel Thuillier, R.A., as Surveyor-General of India, both which officers respectively fill those appointments at the present time.

The charts of the trigonometrical operations are zincographed on a scale of 4 miles to the inch, and the geodetical co-ordinates for each station with azimuths and linear distances are entered upon them, so that each chart forms a brief but complete record of the survey results. Skeleton charts of levels, on a scale of 2 miles to the inch, are also prepared and photozincographed; these show the combined results of both trigonometrical and spirit levelling reduced to the common datum of the mean sea-level of Kurrachee harbour.

Revenue Survey.—The Revenue Survey Branch, in the Bengal Presidency, first commenced in the year 1822. It comprises a scientific periphery admeasurement of the land by means of angular and linear measurements, performed with theodolites and steel chains;

and its operations extend into such parts of the country as are under British administration and yield a fair revenue. It is a definition and survey of village boundaries and estates, and may also be termed a large scale topographical survey, as it affords accurate topography of every district falling within the scope of its operations. The system followed is that of traversing with the theodolite and steel chains, known as Gale's method of land-surveying, modified to secure greater accuracy and efficient checks on both the boundary and interior detail measurements. Large areas are first traversed with the better class of small theodolites having from 12 to 8 inch horizontal circles, starting from an initial station, where the azimuth is observed, to obtain the true bearings of stations in advance, the distances between stations being measured with steel chains twice over and repeated in rough ground, or wherever any doubts arise. These traversed areas, called main circuits, being in the first instance traversed and proved, afford a complete check on the minor or block circuits into which they are subdivided; and these minor circuits, being in their turn traversed and proved true on the basis of the main circuit containing them, reduce the errors in the village boundary work to a minimum. The trifling angular and linear discrepancies which may occur in the village traverse circuits are adjusted *inter se.*

The interior or detail survey, which is filled in by plane-table or compass and chain, rests on these small village polygons, plots of which are furnished to the native plane-tablers. The stations of the main circuits are permanently marked, and the masonry platforms which mark the tri-junctions of villages are, whenever practicable, made theodolite stations. The boundaries of villages are measured by offsets taken to all boundary pillars from the lines enclosing the village polygons, these linear and offset measurements being carefully recorded in the village boundary field-book.

Along the Revenue Survey lines of levels, all masonry platforms marking the junction of three villages which fall on or near the line are invariably adopted as permanent bench-marks. These being all marked prominently on the maps of the Revenue Survey, the entry of the data will be readily and easily made, showing the height of each bench-mark above the mean sea-level, as determined by starting from and closing all the lines of Revenue Survey levels on the Great Trigonometrical stations, or the bench-marks of the principal series of levels of the Great Trigonometrical Survey of India.

In connection with the Revenue Survey, levelling operations were carried on, during 1868–69, in Oudh and Rohilcund, and they have subsequently been extended to the central provinces, Bhamulpoor and Bengal. The object of these is to run series of levels across districts not yet contoured, and to combine the results of the

levelling operations of the Revenue Survey with those already completed, or about to be prosecuted, by the Irrigation Branch of the Public Works Department.

The field mapping is all executed on a scale of 4 inches to the mile.

In addition to the regular professional revenue survey of villages, there has always been a minute measurement of fields for assessment purposes, conducted by native agency, entirely under the collector or settlement officers. These are crude operations after native fashion.

In the presidencies of Madras and Bombay, minute cadastral measurements of fields are in progress under European officers; these surveys are essentially for settlement and revenue purposes, and have no connection with the Indian Survey Department, nor are they under the direction of the Surveyor-General of India.

Topographical Survey.—The Topographical Branch of the Indian Survey Department is under the immediate superintendence of the Surveyor-General of India, and had its origin in the Revenue Survey. Its operations are confined chiefly to hilly and jungle-covered ground, yielding but little revenue, in parts of the country not actually under British management, and in friendly native states along the British frontier; and its object is to obtain a cheap, rapid, and reliable first survey for geographical and administrative purposes. The groundwork or basis of its operations is secondary and minor triangulation dependent on the Great Trigonometrical Survey operations, from which all the initial elements of latitude, longitude, elevation, distance, and azimuth are derived. The triangulation is carried on in a network covering the ground with points or stations at about 3 to 4 miles apart. The instruments employed for the secondary triangulation are vernier theodolites with 12 and 14 inch azimuthal circles; the horizontal observations are taken on four zeros repeated and the vertical angles on two zeros. For the subsidiary or minor network of triangles, theodolites with 7 and 8 inch azimuth circles are used, and the angular measurements are made with two zeros repeated.

The detail work, or delineation of the configuration of the ground, is executed usually on the scale of 1 inch to the mile by means of the plane-table. Some topographical surveys in cultivated or valuable tracts are on a scale of 2 inches to the mile; and a few others, in very broken and wild ground, on a scale of 2 miles to the inch. In addition to the 1-inch survey, the Topographical Branch undertakes the plans of all the important cities, forts, and strongholds in native states; these are mapped on scales varying from 6 to 16 inches to the mile.

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III. THE GEOLOGICAL SURVEY OF INDIA.

(With a Sketch-map.)

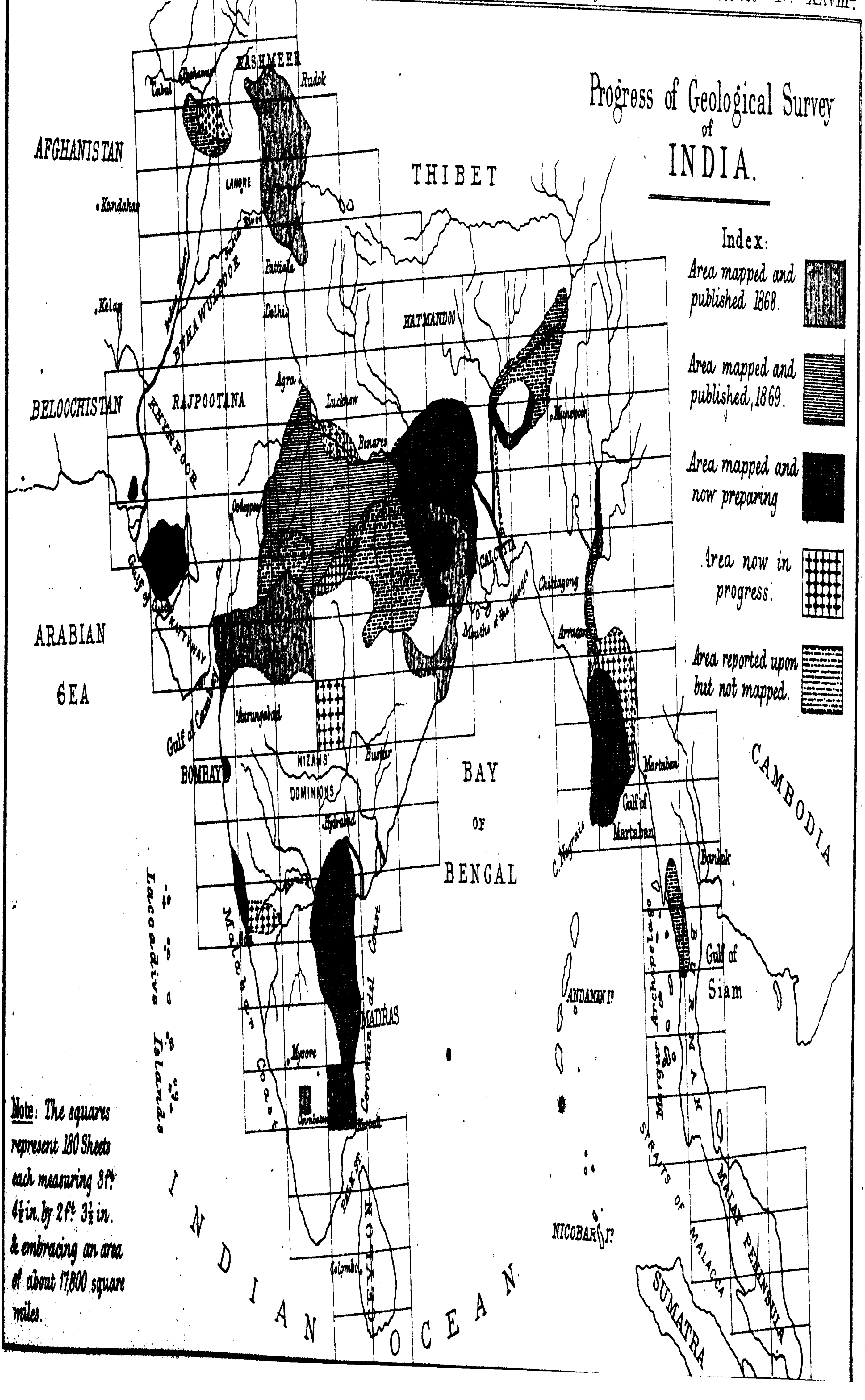
By H. WOODWARD, F.G.S.

SIXTEEN years have now elapsed since the Geological Survey of India commenced its systematic labours, and it may now be interesting to give some account of the progress that has been made, and to note a few of the results to which the Government officers have been led.

Some time beforehand, in 1851, Mr. (now Dr.) T. Oldham, the Superintendent of the Survey, arrived in Calcutta.

The work which he was then required to do was to go from place to place, and, without loss of time, to search for coal and other minerals of economic value; to furnish reports, and thus to indicate by observations in a few places the important results that might be obtained from a detailed survey of the whole of the country. Great were the difficulties with which he had to contend at the outset, and for a long time afterwards; so that not until 1856 was he able to establish that regular system of operations carried on by a staff of officers, small at first, and even in 1863 numbering but fifteen geologists.

No one was better fitted for the task in hand than Dr. Oldham; he had been Local Director of the Geological Survey of Ireland, and was previously Professor of Geology in Trinity College, Dublin.


Progress of Geological Survey of INDIA.
Index:
Area mapped and published 1868.
Area mapped and published, 1869.
Area mapped and now preparing
Area now in progress.
Area reported upon but not mapped.
Note: The squares represent 180 Sheets each measuring 3 ft. 4½ in. by 2 ft. 3½ in. & embracing an area of about 17,800 square miles.
AFGHANISTAN
KASHMEER
Rudok
Cabul
LAHORE
Kandahar
THIBET
Pattiala
Delhi
Kelat
BUHAWULPOOR
HATMANDOO
BELOOCHISTAN
RAJPOOTANA
KHYRPOOR
Agra
Lucknow
Benares
Oodeypoor
CALCUTTA
Chittagong
Mouths of the Ganges
Arracan
ARABIAN SEA
Gulf of Cambay
Aurungabad
BOMBAY
NIZAMS' DOMINIONS
Hydrabad
Bustar
BAY OF BENGAL
Martaban
Gulf of Martaban
C. Negrais
CAMBODIA
Bankok
Gulf of Siam
Laccadive Islands
Malabar Coast
Coromandel Coast
MADRAS
Mysore
ANDAMIN Is.
Mergui Archipelago
BURMAH
NICOBAR Is.
STRAITS OF MALACCA
MALAY PENINSULA
SUMATRA
CEYLON
Colombo
INDIAN OCEAN

With his small band of Geologists, the Survey was carried on with vigour, and periodical reports were published, accompanied by maps, geologically coloured, and sections of the country described.

The value of the establishment was soon appreciated by the public, and numerous applications for reports on geological matters were made, as well as for aid in analyses of coal, minerals and ores, of soils, water, and in assays. Such information and assistance was given to many private individuals, as well as to Government departments and to companies.

The earlier observations were, as might be expected, fraught with much difficulty. But few and isolated notices, compared with the size of the country, had been written upon it. The labours of Dr. Carter, of Bombay, of the Revs. Hislop and Hunter, Presbyterian missionaries in Tinnevelly, and some others, had certainly done a little towards paving the way for a classification of the rocks; and Mr. Greenough had, in 1854, after many years' labour in compilation, prepared a map of India, upon which he had depicted all that was then known concerning the geology of the country.

Dr. Oldham,* however, found it necessary to establish several new groups to receive (provisionally) the various rocks that were met with, inasmuch as for many—and these some of the most widely-extended and important groups of rocks—there was no definite horizon from which to work either up or down. Over thousands and tens of thousands of square miles not a fossil was found, save some vegetable remains, affording, at the best, but very imperfect evidence. The richly fossiliferous rocks of the Himalaya and Sub-Himalaya being widely separated from all the rocks of the Peninsula by the broad expanse of the Alluvium which unites the valleys of the Ganges and Indus, it was impossible to trace out, by their aid, any superposition.

To endeavour to remedy this, it was found advisable to examine many distinct tracts, and to make more or less rapid observations on distant parts, which, although interfering with the continuous progress of the Survey, were generally of essential service in leading to definite results on important geological points, which, in the ordinary progress of the work, could not have been arrived at for many years to come.

The climate of India necessarily restricts the work to certain portions of the year. The working season lasts about seven months, and differs very materially in the southern part of the Peninsula from that in Bengal. In the latter district, the close of the Indian financial year (the 31st March) nearly coincides with the close of the field season. In Madras the season is then not half over.

* See Mr. Horner's Anniversary Address to the Geological Society of London. 1861.

Considering the great exposure to which all field-geologists working in the open country are unavoidably subjected, and the necessity for their visiting, and often remaining in, the most malarious and unhealthy parts, it is not surprising to learn that the whole staff are seldom at work at one time. The illness of one or more, and the necessity for leave of absence, is generally recorded in the Annual Reports. But it is grievous to learn the loss by death of five or six officers since the Survey has been in operation, whilst several have been forced to resign from ill-health.

These causes have occasioned much loss of time. It is seldom possible, Dr. Oldham remarks, to meet with persons qualified to supply the vacancies immediately. There is, moreover, absolute necessity for a considerable amount of training, occupying generally a year, before any newly-appointed Assistant can become really useful, and able to carry on alone the mapping of a district.

The pecuniary temptations furnished to individuals to join the Survey are not very great, the *maximum ratio* of pay being 500 and 600 rupees per month, but this is only obtainable after eight or ten years' service. The salary, as on the British Survey, is very fair to commence with, but equally discouraging in prospect.

The latest report of Dr. Oldham, dated the 3rd January, 1870, is accompanied as usual by an index-map, showing the area surveyed, and published to the end of 1869, and that in progress. A reduced copy of this map accompanies our notice.

The Atlas of India, which includes Burmah and the Malay Peninsula, comprises about 180 sheets, portions of about 64 of which have been mapped, while others have been visited and reported upon.

A very large area has not yet been surveyed topographically, so that the direction of the detailed mapping by the Geological Survey has some restrictions. The size of the sheets is 3 feet 4½ inches by 2 feet 3½ inches, and each contains an area of about 17,824 square miles.

The principal part of the work has been carried on in Central India. The faultiness of the existing maps of the country was found a serious drawback to successful progress, but so far as possible they were corrected, and every effort was made to render them of the utmost service. It was soon found, however, that the character of the geological work must be suited to the available maps of the district, and with very imperfect maps to attempt great detail would be useless. For all practical purposes, the boundaries of the geological formations could generally be fixed with sufficient accuracy.

But few sheets have been entirely surveyed. This, however, would be accounted for by the necessity, previously stated, of examining many different and distant parts for the purpose of arriving

at a classification or knowledge of the order of superposition of the rocks in India; and when the vast area embraced by each sheet is taken into consideration, it is not surprising that few have been completed.

A glance at the map best shows the amount of field-work that has been done, and considering the many difficulties and dangers that have had to be encountered—not forgetting the disturbed state of the country during the Indian mutiny in 1857—we must congratulate the Survey on the great progress it has made.

Besides the preparation and publication of the geological maps, the Survey now maintains three periodicals of letter-press.

The first part of the 'Memoirs' appeared in 1856, and since then six volumes have been completed, containing thirty-two geological reports (over 2200 pp. of letter-press), and the first part of vol. vii. has recently been published. All are well illustrated with maps and sections.

Particular attention has been given to the coal-bearing deposits. The 'Memoirs' contain reports on the Coal-fields of Talchir, Ranigunj, Jherria, Bokaro, Ramgurh, &c.

The coal-fields of Bokaro and Ramgurh belong to the ordinary, or Damuda series.

In the Jherria coal-field, the two series, Talchir and Damuda, are developed.

The lower, or Talchir, contains no coal.

The Damuda series contains many seams, very irregular, and varying in thickness from a few inches to 20 feet and more. Numerous coal-seams are much injured by trap-dykes, which have ramified through them, and which have rendered the coal useless. There is also a general tendency to ignition in all the seams, owing, it is thought, to the presence of iron pyrites, which gives rise to spontaneous combustion. Metamorphism is produced in the shales in proximity, giving to them the character of well-burnt bricks.

Dr. Oldham calculates that there is an available quantity of coal in this Jherria field of about 465,000,000 cubic yards, or, roughly, tons of coal.

In Sinde there is a lignitic coal of Lower Tertiary age, but not worth working. In one of his earlier reports Dr. Oldham noticed the existence of Tertiary coal by the river Irrawaddy, near Prome.

Coal of excellent quality has been found in Assam, which lies near the river Brahmapootra, convenient for transport by water.

Considerable doubt attached to the age of the coal-fields of Damuda, Talchir, and Nagpur. The reported discovery in them of certain plants was thought to place them in the Triassic or Oolitic period. But it has since been ascertained that these remains occur in shales above and distinct from the Coal-measures.

Comparisons have been made of late between the several series

of sandstones, &c., associated with the coal in Bengal and those of Central India. The vast extension and great constancy in mineral character of the Talchir rocks (which form the base of the great coal-bearing series) have been fully established, and the thinning out of the beds in passing to the west has received further support. The entire Coal-formation, which in the east gives five well-marked subdivisions (in ascending order, Talchir, Barakar, Ironstone shales, Ranigunj, and Panchet), becomes, at a short distance to the west, only a threefold series, comprising the Talchir, Barakar, and Panchet subdivisions. Additional proofs have been brought forward to show that on the large scale, the present limits of these Coal-measures coincide approximately with the original limits of deposition, and are not the result of faulting, or even mainly of denudation.

And Dr. Oldham expresses his opinion that the great drainage basins of India were on the large scale marked out, and existed (as drainage-basins) at the enormously distant period which marked the commencement of the deposition of the great plant-bearing series. In this point of view, local variations in the lithological type, local variations in the thickness of the groups, and even their occurrence or non-occurrence, are only necessary consequences of the mode and limit of formation.

In 1861 Dr. Oldham gave a summary statement of the amount of coal raised throughout India for the past three years, which was about 850,000 tons. The total amount of coal raised in India generally was, in 1858, about 226,140 tons; in 1859, about 347,227 tons; and in 1860, about 370,206 tons. Of this quantity the Ranigunj field yielded by far the greater part. The only mode of transport, however, from this field was by the river Damuda, a stream only navigable during the freshes of the rainy season, after which it becomes so dry that no more coal can be sent to market until the next season.

In 1867 Dr. Oldham made a report on the Coal-resources of India.* The extensive fields which occur are not distributed generally over the country, but are almost entirely concentrated in one, a double, band of coal-yielding deposits, which with considerable interruptions extends more than half across India, from near Calcutta towards Bombay.

Little more than surface workings are carried on—the deepest pits scarcely exceed 75 yards, while certainly one-half of the Indian coal which has been used up to the present date has been produced from open workings or quarries.

Dr. Oldham concludes that out of the whole series of Indian coals, the very best of them only reach the average of English coals, and that on the whole they are very inferior to them. It should, however, be borne in mind that until all the fields are carefully

* Being a return called for by the Right Hon. the Secretary of State for India.

mapped, any estimates of the Coal-resources and production of British India must be defective.

Besides the coal-reports, the 'Memoirs' contain papers on the gold-bearing and other economic deposits, also many describing the geology generally and physical geography of particular areas. Some few treat of palæontology.

One very important paper describes the Vindhyan series, as exhibited in the North-Western and Central Provinces of India. The district described included the greater part of Bundelkund. The Vindhyan series is divided into an upper and a lower division, the former gives rise to great table-lands, the latter furnishes more diversified scenery. The area affords many striking instances of the power and effects of subaërial denudation on a grand scale. As yet the Vindhyan rocks have yielded no fossils; they appear to be older than the Talchir, and may possibly turn out to belong to a period about the age of the Devonian. Lithologically they consist of alternations of limestones, shales, sandstones, and conglomerates, often distinguished by local names, as for instance the "Bijigurh shales." Some of the beds furnish good building stone.

In order to gain a more rapid publication of many isolated facts noticed during the progress of the Geological Survey, and which were scarcely adapted to the 'Memoirs,' a new publication called the 'Records' was started in 1868. The series contains notices of the current work of the Survey, lists of contributions to the Museum and Library, &c., and it is intended also to publish analyses of such books published elsewhere as bear upon Indian geology, and generally to notice all facts which come to light illustrative of the geology of Hindostan. The third volume is now in course of publication.

Among the numerous published Reports the following appear most worthy of special notice.

The Surat Collectorate, in the Bombay Presidency, although a comparatively flat country, possesses many features of geological interest. Traps, ranging from basalt to a soft shaly-looking amygdaloid, are met with, and resting unconformably upon these is the great Nummulitic series. This consists of sandstones, conglomerates, and limestones, with nummulites, molluscs, fossil-wood, and fragments of bone. Alluvium covers a large extent of the district, and the cotton (or black) soil covers it over many large tracts of the country. This soil seems to be the residuum left by the decomposition of an alluvium largely composed of volcanic (trappean) *débris*. It usually occurs in districts in which trap-rocks abound, as for example in the Poorna valley, West Berar.

The Poorna alluvium is of considerable depth, in places about 150 feet. Much of it produces efflorescences of salts, chiefly of soda; and in many places the wells sunk in it are brackish or salt.

Comparisons have recently been drawn between the Alluvial deposits of the Irrawadi and the Ganges. Every river that discharges its waters into the sea has the character of its deposits influenced according to whether the area be in a state of subsidence, quiescence, or of elevation. Generally in every large river-basin two distinct alluvial deposits will be met with. The older of these may be either marine (estuarine) or fluviatile (lacustrine), or of a mixed and alternating character; but the newer group is essentially fluvio-lacustrine, and directly produced by the existing river. While no very great thickness of the newer stratum can anywhere have been deposited without a corresponding subsidence of the area, a very large accumulation of the older or estuarine deposit may have taken place during an elevation of the area covered by it.

The Ganges and Irrawadi present examples of rivers subjected, respectively, to the former and latter conditions. The alluvium of the Ganges, as ascertained from a well-boring at Fort William, consists of 70 feet of the newer or fluviatile deposit, resting on the denuded surface of the "kunker clay." This clay is regarded as an estuarine deposit accumulated during an upward movement of the land. The Gangetic area is now considered to be undergoing depression at a rate adequately counterbalanced by the accession of sediment brought down by the river. The alluvium of the Irrawadi belongs almost entirely to the older group, this river-delta being at the present time in precisely the same condition as was the delta of the Ganges when the first layers of its alluvium, 70 feet below the present surface at Calcutta, were being deposited. The difference in the fertility of the two areas is attributed to the greater richness of the newer alluvium, and hence the inability of the delta of the Irrawadi to compare with that of the Ganges in agricultural produce.

The geology of the neighbourhood of Madras is noticed in the third volume of the 'Records.' The greater part of this district is occupied by rocks of Secondary, Tertiary, and Recent ages, the remainder is taken up by metamorphic rocks, forming part of the great gneissic series of Southern India. Some time previously, beds of magnetic iron-ore were pointed out in the metamorphic gneiss rocks of the Madras Presidency, the supply of which was considered to be practically inexhaustible.

The Rajmahal plant-beds consist of conglomerates, sandstones, gritty clays, and shales.

The Laterite deposits are also pointed out. They comprise clayey conglomerates, gravels, and sands, which graduate one into the other. The gravels contain pebbles of quartzite and gneiss, mixed with pisiform ferruginous pellets. Other deposits called the Conjeveram gravels are noticed; they differ from the laterite beds in the absence of ferruginous matter. Both appear to contain imple-

ments of human manufacture in the shape of axes and spear-heads made of chipped quartzite pebbles, and of the same types as those which occur in the gravels of Western Europe. They were spread rather widely over a large extent of area in the country to the west and north of the city of Madras, and have been made of the best substitute which this portion of the country could afford for flint, namely, the very hard and semi-vitreous quartzites of the Cuddapah series.

In gravel, situated near Pyton on the banks of the Godavery, an agate-flake has been found, which is undoubtedly an artificial form. It is figured in vol. i. of the 'Records.'

We have but briefly and imperfectly noticed a few of the more important results arrived at by the energetic labours, *in the field*, of Dr. Oldham and the officers of the Geological Survey. This work—superintended by Dr. Oldham—has been carried out by the many able assistants who have served under him, among whom we may mention H. B. and J. G. Medlicott, H. J. and W. F. Blanford, C. Æ. Oldham,* W. Theobald, jun., F. R. Mallet, A. B. Wynne, R. B. Foote, T. W. H. Hughes, W. King, jun., F. Fedden, &c.

We will now turn our attention to the palæontological work.

A Museum of Economic Geology was established at Calcutta in 1840, and in 1856 it was placed in connection with and under the same superintendence as the Geological Survey of India. There are also Museums at Madras, Bombay, and Kurrachee.

During the progress of the Survey numerous fossils have been collected, and specimens are being constantly added to the Museum. Indeed Dr. Oldham reports that they increase so rapidly that no room can be found for their proper exhibition, and in the examination and description of them it is impossible to keep pace. During the year 1869 more than 20,000 specimens passed through the hands of the curator and his assistant. A suitable building is, we are informed, now in course of erection at Calcutta, where the fine collections already brought together will be properly arranged and exhibited.

One of the more richly fossiliferous tracts is at Spiti and Rushpu in the Himalayas, where representatives of Silurian, Carboniferous, Triassic (Lilang series), Rhætic (Para limestone), Lower and Middle Lias, and three subdivisions of the Jurassic period, and also Cretaceous rocks are believed to occur.

In order to figure and describe the species of organic remains collected by the Survey, the 'Palæontologia Indica' was instituted. This quarto publication is issued in fasciculi, each containing about six plates, and published once every three months. Five series of these fasciculi have been published.

* This able geologist died 30th March, 1869, aged 37 years. See Obituary, 'Geol. Mag.,' vol. vi., p. 240.

The *first series* was printed in 1861, and treated of the Fossil *Cephalopoda* of the Cretaceous rocks of South India, containing the *Belemnitidæ* and *Nautilidæ*, by H. F. Blanford; the *Ammonitidæ*, by Dr. F. Stoliczka, formed matter for the *third series.*

The Cephalopoda were found to include 146 species, of which nearly one hundred were *Ammonites*, three only *Belemnites*, whilst of Nautilus there were 22 species, &c. Thirty-seven of these species were found identical with species known in Europe and other countries. Ninety-six quarto plates are devoted to the illustration of these fossils.

The Gasteropoda of the Cretaceous rocks form the subject of the *fifth series;* they are illustrated with sixteen plates, and are described by Dr. Ferdinand Stoliczka.

Two hundred and thirty-seven species of Gasteropoda are described. Among them, four species of *Helicidæ* are deserving of special attention from the rarity of land-shells in these Cretaceous rocks, and particularly as they are said to belong to types still found living in the same or neighbouring districts.

Dr. Stoliczka considers that the South Indian Cretaceous deposits only represent the Upper Cretaceous strata, beginning with the Cenomanien. The larger number of representative species were found to agree with the Turonien. The original notion of representatives of Neocomian beds existing in South India loses support from the more complete examination and comparison of the species.

The *second series* of the 'Palæontologia Indica' is devoted to the Fossil Flora of the Rajmahal series (Jurassic), six fasciculi of which have been published. The descriptions are by Dr. Oldham and Professor Morris. The Rajmahal beds occur near Madras, in Bengal, and Kutch. At Madras the beds contain no carbonaceous matter, which in their equivalents in other parts of India occurs so largely as to form coal-seams. The plant-remains occur chiefly in a white shale. They include *Palæozamia, Dictyopteris, Tæniopteris, Pterophyllum, Pecopteris, Stangerites, Poacites,* &c.

The *fourth series* on the Vertebrate Fossils of the Panchet rocks is by Professor Huxley, and is illustrated with six plates. These remains consist of numerous fragmentary and sometimes rolled bones, the majority being vertebræ, with a few teeth, portions of crania, &c. They were discovered in a stratum of conglomerate sandstone exposed by the Damuda river near Deoli, fifteen miles west of Raniguni, and they are of great interest as being the first remains of vertebrata discovered in the great group of rocks associated with the coal-bearing formations of Bengal. They proved to belong to a peculiar group of fossil reptiles (*Dicynodontia*) hitherto only known from South Africa. The strong analogy which these South African rocks offer to some of the Indian rocks had been insisted on by Dr. Oldham, before this discovery, on the strength of

the plant-remains alone, and this has been strangely confirmed by the discovery of reptiles of the same type (*Dicynodontia*).

Very many years must necessarily pass away before the Geological Survey of India is completed, nor can Dr. Oldham and his present staff hope to see its accomplishment, but they have done sufficient already to indicate the great geological features of the country, and we may hope to see in one of their future publications, a table of succession of the Indian strata as far as at present determined, with their probable European equivalents.

IV. RAINFALL IN ENGLAND.

By W. Pengelly, F.R.S.

As regularly as the new year comes, and very speedily afterwards, come Mr. Symons's 'British Rainfalls,' containing the well-tabulated results obtained by many hundreds of rain observers whose gauges are spread over Great Britain and Ireland, as well as the adjacent isles.

The data contained in these annual publications are of great interest, not only in themselves and as they stand, but because they are capable of being worked up and discussed in various ways, some of which I will now proceed to illustrate.

The Rainfall of England and Wales.—During 1869, there were in Great Britain south of the Tweed and Solway no fewer than 1093 gauges at work, giving an average of about 21 for each county, but, as may be supposed, without any approach to uniformity of distribution. They were most thickly strewn in Middlesex, and most sparingly in Montgomeryshire, there being one gauge for every 5973 acres in the former, and for every 284,060 acres in the latter; that is relatively about forty-seven times as many gauges in the one as in the other. On the average, there was in the entire kingdom one gauge on every 34,149 acres; hence, were the distribution uniform, each gauge in England and Wales might be supposed to occupy the centre of a square measuring 7·3 miles in the side.

It is eminently creditable to the zeal and perseverance of their meteorologists that the mountainous and thinly-populated counties of Carnarvon, Cumberland, and Westmoreland, were amongst those in which the relative number of gauges exceeded the average for the entire country; thus for every ten gauges in England and Wales as a whole, there were 10·5 in Carnarvonshire, 18·4 in Cumberland, and 25·5 in Westmoreland. In the last, moreover, there were no fewer than twelve gauges on ground upwards of 1000 feet above the sea, three upwards of 2000 feet, and one at the height of

3200 feet. Westmoreland had five gauges more than 1000 feet high; and though Carnarvon had none exceeding 850 feet in height, the returns from every gauge in the county were in every respect complete, as they contained full information as to height above the sea and the ground, the total annual rainfall, the number of wet days, and therefore of the average wet-day rate of rain.

The stations varied in height from the sea-level, at Hull, to 3200 feet above it, at Scafell Pike in Cumberland. The least county average height was 53 feet, in Cambridgeshire; the greatest was 715 feet, in Radnorshire; whilst that for the entire kingdom was 297 feet. This general average was surpassed in twenty-five counties, but not reached in the remaining twenty-seven.

The tops of the gauges were by no means at one uniform height above the ground on which they stood. In several cases they were level with the surface, whilst one at Cockermouth was 100 feet above it. Taking the counties as separate wholes, the least average height was 13 inches in Leicestershire, and the greatest 8 feet 7 inches in Cambridgeshire; while the mean height for the entire country was 2 feet 9 inches. This general average was exceeded in twenty-four counties, but not reached in twenty-six.

During the four years ending with December 31st, 1869, the least annual rainfall at any station was 7·84 inches—the receipts in 1869 of a gauge at Sheerness, the top of which was 70 feet above the ground and 79 feet above the sea; whilst the greatest was 207·49 inches, received in the same year, in a gauge 6 inches above the ground, and 1077 feet above the sea, at the Stye in Cumberland. During the four-year period just named the average annual rainfall in the different counties as separate wholes varied from 68·91 inches in Cumberland to 22·55 inches in Bedfordshire; the average for the entire kingdom being 35·37 inches. The three numbers were as 195 : 63 : 100. The general average was exceeded in eighteen counties but not reached in thirty-four; the former, or "wet" counties, being to the latter, or "dry" ones, as 1 : 2 nearly.

According to the Registrar-General, England and Wales contain 37,324,915 statute acres; hence, with an average rainfall of 35·37 inches, they every year receive 4,792,261,544,086 cubic feet of rain; that is, a quantity sufficient to fill a canal having an uniform breadth and depth equal to those of the Thames at low water at London Bridge ($700 \times 12 \cdot 5$ feet), and a length of 103,721 miles, or more than four times the circumference of the earth. Taking the weight of a cubic foot of water at 1000 oz. av., England and Wales annually receive 133,712,677,011 tons of rain. Were the entire rainfall of the year converted into a hailstorm it would be a globe having a diameter of 4730 feet = ·9 miles.

The eighteen "wet" counties are, in descending order, Cumber-

land, Merionethshire, Westmoreland, Montgomeryshire, Carnarvonshire, Cardiganshire, Cornwall, Pembrokeshire, Monmouthshire, Glamorganshire, Caermarthenshire, Lancashire, Devonshire, Brecknockshire, Radnorshire, Anglesea, Derbyshire, and Somersetshire—those, in short, which, with the exception of Cheshire, Denbighshire, and Flintshire, form our western coast from the Solway to the Land's End, including the Bristol Channel to the eastern margins of Monmouth and Somerset shires, together with the inland mountain counties of Montgomery, Brecknock, Radnor, and Derby. Obviously our rains come from the west and south-west; high lands have a greater rainfall than those which are low; and, as a corollary, districts having loftier lands between them and the Atlantic must receive less rain than those not thus sheltered,—a truth well illustrated by the comparative dryness of Cheshire, Denbigh, and Flint shires, which lie on the dry side of Carnarvonshire, Anglesea, and Ireland.

In the provisional language of meteorologists, those days are termed "wet" on which not less than ·01 inch of rain falls in the twenty-four hours. During the four years already mentioned, the greatest number of wet days recorded in one year at any station was 315 in 1866, at Patterdale Hall, in Westmoreland; and the least number was 77 days at Beeston Lock, Nottinghamshire, in 1868. The greatest county annual average for the same period was 207 days in Merionethshire, the least 137 days in Bedfordshire, whilst for the entire kingdom it was 169 days: the three numbers being as 122 : 81 : 100.

In twenty-two counties the general average number was exceeded, whilst it was not reached in twenty-eight; the former group included all the counties of excessive rainfall, with the exception of those of Brecknock and Pembroke.

From what has been stated above, it appears that the county of greatest average rainfall was not that of the greatest average number of wet days, and that the difference between the rainfall extremes was greater than that between those of the number of wet days, it being 132 per cent. in the former, but no more than 41 per cent. in the latter case. In other words, though a great annual rainfall, and a great number of wet days may be said to go together, the former, instead of depending entirely on the latter, depends also on the average wet-day rate of rain.

Cumberland, as we have seen, received, on the average, 68·91 inches of rain on 192 days per year; hence its average wet-day rate of rainfall was ·36 inch (= 68·91 ÷ 192), and this was the maximum. The minimum was that of Cambridgeshire, amounting to no more than ·15 inch; whilst the average for England and Wales, as a whole, was ·22 inch; the three numbers varying as 164 : 68 : 100.

Fourteen counties, all of them having excessive rainfalls, exceeded the general average wet-day rate.

It may be convenient here to recapitulate in a tabular form the principal facts just established in connection with the three pluvial elements of England and Wales, and which show that the rainfall of a district depends on the wet-day rate of rain rather than on the number of wet days.

	Max.	Min.	Mean.
Average annual *relative* rainfall	195	63	100
Average annual *relative* number of wet days	122	81	100
Average *relative* wet-day rate of rain	164	68	100

On taking the "wet" and "dry" counties as two distinct wholes, their pluvial elements stand as below:—

	Actual.		Relative.	
	Wet.	Dry.	Wet.	Dry.
Annual average rainfall	49·14 in.	28·68 in.	171	100
Annual average number of wet days ..	185 days	160 days	116	100
Annual average wet-day rate of rain ..	·27 in.	·18 in.	150	100

The Influence of Height above the Ground on the Rainfall.— It has long been known that at the same station a gauge on or near the ground receives more rain than one higher above it. Dr. Dalton stated, in 1802, that the ratio of the quantity of rain collected on the top of St. John's steeple, Manchester, to that collected on the ground in the vicinity, about 50 yards below, was in summer as 2:3 nearly, and in winter as 1:2 nearly.*

Mr. Symons's 'British Rainfall' extends over the ten years beginning with 1860; and at several of the stations whence he receives returns there are two or more gauges at different heights above the ground. Omitting all whose vertical distances are less than 10 feet, and taking the highest and lowest only at the same station, there were in Great Britain and Ireland 226 cases spread over the ten years which are available for the discussion of the question immediately under notice.

The "vertical gauge-distances" varied from 10 feet to 99·5 feet, and averaged 40·5 feet. The total amount of rain received by all the lower gauges was 6812·02 inches, and by the upper ones 5707·98 inches; showing an actual defect of 1104·04 inches, or a relative defect of 16·3 per cent. This, divided equally between the 226 cases, gives a total deficit of 4·885 inches each per year. Dividing, again, by the average gauge-distance, or difference of height

* 'Monthly Magazine,' vol. xiv., p. 5. 1802.

(40·5 feet), the result is an annual average deficit of ·12 inch, or ·4 per cent., for every foot of elevation above the ground. In other words, if the rainfall, received during a year by a gauge on, or a few inches above, the ground, be divided into 1000 equal parts, for every foot a second gauge is placed vertically above this, it will, *on the average*, receive four such parts fewer.

It is obvious that this *uniform* average "foot-defect" of ·4 per cent. of the receipts of the lower gauge presupposes that the lower gauges are all at the same small height above the ground, and that for a given depth or zone of atmosphere the actual deficit is the same, whether the zone be at a high or low level. The first is unfortunately anything but true, as some of the lower gauges are level with the surface, whilst others are as much as 8·5 feet above it.

Waiving this however, interesting information on the second point is contained in the returns, tabulated below, from Southampton, Oxford, and Preston, and which have been selected from the entire list simply because they extend over a greater number of years than any of the others, and because the difference in the heights of the gauges, that is, the depth of the zone of atmosphere on which the experiments were made, was not the same at any two of the stations.

Stations.	Vertical gauge-distances.	Relative Foot-defects.										
		1860.	1861.	1862.	1863.	1864.	1865.	1866.	1867.	1868.	1869.	Means.
	ft. in.											
Southampton	18 1	1·03	·92	1·19	·97	1·03	1·33	1·04	·55	·66	·63	·93
Oxford . .	22 9	·64	·59	·65	·78	·81	·69	·86	·30	..	·28	·60
Preston . .	49 5	·23	·27	·32	·31	·25	·27	·34	·34	·42	·26	·30

An inspection of the Table shows that whilst at each station there were fluctuations from year to year, the foot-defect was invariably an inverse function of the vertical gauge-distance. In other words, if a series of gauges be placed vertically above one another, at uniform distances, the first or lowest will receive, on the average, more rain than the second, which in its turn will receive more than the third, and so on; but the difference between the receipts of the first and second will be greater than that between those of the second and third, and so on.

The foregoing Table contains twenty-nine annual returns from the three stations collectively. If with them we include all the annual returns from stations having gauges differing in height from 10 to 70 feet, and form them into six groups, such that the first shall be made up of those only having a gauge-distance of from 10 to 20 feet, the former alone inclusive; the second, of those whose distance ranged from 20 to 30 feet; and so on to the sixth or last; we get the following Table, in which the Southampton returns just

given, obviously belong to the first group, those from Oxford to the second, and those from Preston to the fourth:—

Vertical gauge-distances. in feet.	Number of Annual Returns.	Average Foot-defect, per cent.
From 10 to 20	22	·939
„ 20 to 30	53	·512
„ 30 to 40	50	·395
„ 40 to 50	35	·378
„ 50 to 60	19	·305
„ 60 to 70	13	·374

From the foregoing figures, it appears that if the contents of the lower gauge be divided into 100,000 equal parts, the upper gauge will, on the average, receive 939 fewer such parts for every foot of elevation, provided such elevation be not less than 10 nor more than 20 feet; or 512 fewer such parts per foot provided the vertical gauge-distance be not less than 10 nor more than 30 feet, and so on.

A glance at the last or right-hand column shows: 1st, that, with one exception, the foot-defect diminishes with increased vertical gauge-distance; 2nd, that the difference between two consecutive foot-defects becomes less and less with increase of difference of elevation, and almost disappears at the height of 70 feet.

At certain stations, as Cardington and Cockermouth, there are three gauges, each at a different height above the ground, whose receipts are tabulated below:—

Stations.	Height of Gauges.		Actual Rainfall in inches.						Mean Relative Rainfall.	Mean Foot-defect, per cent.
			1865.	1866.	1867.	1868.	1869.	Means.		
	ft.	in.								
Cardington	0	0	27·25	26·88	23·57	21·94	21·25	24·18	100	..
„	3	6	26·18	25·53	22·26	21·30	20·33	23·12	96	1·14
„	36	0	22·23	21·37	17·26	16·94	17·44	19·05	79	·58
Cockermouth	0	6	..	50·77	38·35	50·12	46·31	46·39	100	..
„	6	6	..	48·19	36·29	48·02	44·48	44·21	95	·83
„	100	0	..	31·30	20·07	27·10	22·86	25·33	55	·45

Here, as before, the receipts of the gauges, at the same stations, were greater when nearest the ground.

The difference of receipts increased with increased difference of elevation.

The deficit, per cent. per foot, became less as the difference of height became greater.

And on comparing the results from the two stations, it appears

that whilst a difference of 3·5 feet in vertical gauge-distance gave a foot-defect of 1·14 per cent. at Cardington, a distance of 6 feet gave a foot-defect of only ·83 per cent. at Cockermouth; and that whilst a vertical gauge-distance of 36 feet at the former gave a foot-defect of ·58 per cent., a distance of 99·5 feet at the latter gave a foot-defect of no more than ·45 per cent.

Enough has probably now been said to show, what indeed has long been known to meteorologists, the importance of the height of the gauge above the surface on which it stands, with the consequent absolute necessity of this height being everywhere the same if we are to attach any meaning to the "Rainfall of District," or if rainfall statistics are to be of any scientific value.

Devonshire, for example, is one of the "wet" counties of South Britain, and, from its situation, Plymouth might have been expected to have been one of the "wet" stations of the county. This expectation is quite in harmony with the popular belief, which finds expression in such remarks as "It always rains at Plymouth." "Don't forget to take your umbrella when you go to Plymouth," and so on. Nevertheless, the published returns do not confirm it. The average annual rainfall of the county during the four years ending with December 31st, 1869, was 42·40 inches, whilst at Plymouth it was no more than 39·45 inches, that is a deficit of 7 per cent. If the figures are to be trusted then, Plymouth is for Devonshire a "dry" station, at least so far as the annual rainfall is concerned, whatever it may be with regard to the number of wet days, about which no returns are made. The case is rendered by no means less remarkable when we turn to the other stations in the neighbourhood, all of which confess that they are "wet." Thus Ham, Saltram, and Ridgeway are all within 4 miles of it—the first in a north-westerly, and the second and third in a north-easterly direction —all farther from the sea, and all have their gauges on less elevated ground; all, in short, have conditions likely to betoken a less rainfall, yet their average annual falls, during the four years so frequently spoken of, have exceeded the county mean by 4, 9, and 16 per cent. respectively. The solution of the problem, however, is not far to seek; it lies in the fact that whilst all the other stations have their gauges very near the ground, the Plymouth gauge is 35 feet above it.

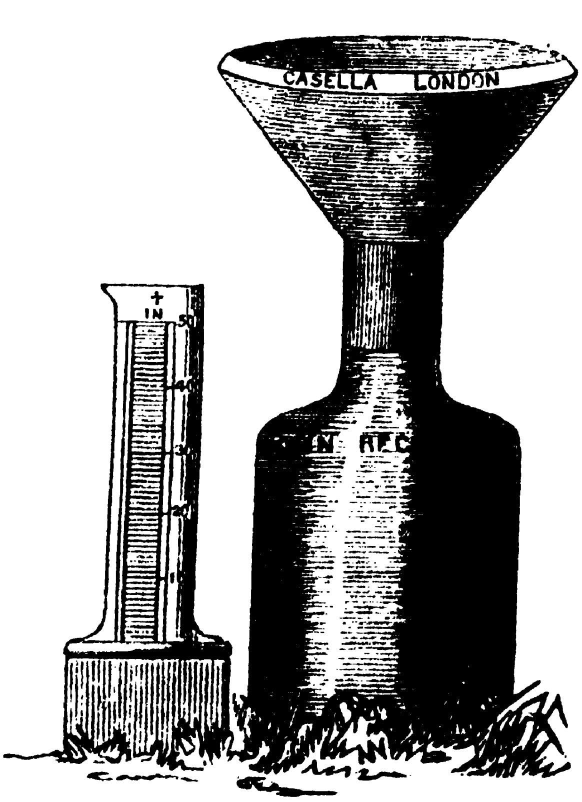
Two other Devonshire stations, Tavistock and Mount Tavy, tell the same story. They are barely a mile apart, and very nearly at the same height above the sea, but the average rainfall of the latter exceeds that of the former by upwards of 12 per cent.—a fact for which no other explanation can or need be given than the sufficient one that the Mount Tavy gauge is only one foot, whilst that at Tavistock is 20 feet, above the ground.

In this age, so famous for the application of science to commercial

purposes, it surely ought to be possible to turn to account the defective receipts of rain gauges high above the surface; and in the absence of a better, perhaps the following suggestion may be of service:—Watering-places and other towns of fashionable and wealthy resort, are always naturally desirous of advertising their attractions. Knowing that their visitors dislike rain, their business is clearly to prove that they are remarkably exempt from it. It is true that a wet day is comfortless and a bore simply because it *is* wet, not because the rain is or is not heavy; hence all that is necessary is to place the town gauge high above the ground, make no record of the number of wet days, publish the annual rainfall thus ascertained, and with it those of towns which have no temptation to this form of utilization. The rainfall will undoubtedly stand in very favourable contrast with that of any of the other towns, and the general public will readily conclude that the wet days were correspondingly few.

Seriously, however, our method of collecting rainfall data is anything but satisfactory, and the figures must fail in the rigid accuracy which science requires.

In concluding this part of my paper, I venture to express the hope that at no distant day all observers will employ gauges of the same size and construction, which shall be tested before being located; that they shall all be at one uniform small height above the surface; that the ground on which they are placed shall be at least approximately level, and quite unoccupied for some distance from them; that none of them shall be placed on buildings, since these, especially when large, cannot but be thermal agents and affect the rainfall; that, with the exception of a few very elevated stations, the number of wet days shall be duly recorded; and that, for ascertaining the exact relation of rainfall to height above the surface, a series of such gauges shall, at least, at one station in each county, be placed practically in the same vertical line at uniform successive distances, say of 10 feet.



Without intending to express any doubt respecting the accuracy of other gauges, it may be stated that probably none are to be preferred to the "five-inch gauge" made by Mr. Casella, under the auspices of the British Association, and which, through the kindness of the maker, is figured above. It consists of a Receiver, a Reservoir, and a Metre. The last, of course, requires no descrip-

tion; and the reservoir may be dismissed with the remark that it is a bottle of stone or glass, 9·7 inches high. The Receiver is a copper circular funnel, 5 inches in diameter, 4·8 inches deep, and terminating in a tube 8·5 inches long and ·3 inch in internal diameter. Outside this, and soldered to the bottom of the funnel, is a cylindrical phlange, 2·25 inches deep, and having between it and the tube a space for the reception of the head of the reservoir, which it exactly fits, so that when united a horizontal section through the phlange would disclose three tightly-fitting concentric tubes. The phlange keeps the receiver steady, prevents the rain which falls on the outside of the funnel from leaking into the bottle, and reduces to a minimum the evaporation of the contents of the reservoir. When fitted together the height of the instrument is 14·1 inches; but when in use it is placed firmly in the ground, and should have its top 9 inches above the surface.

Supposed Influence of the Moon on the Rainfall.—That the moon is very influential in, or at least closely connected with, all changes of the weather, is a belief at once widely spread and deeply rooted. Our satellite can neither be full, nor new, nor "fill her horns," without, as is popularly believed, causing or indicating some alteration in the state of the weather. If she is caught "lying on her back," or, in other words, if, when she is less than a semicircle, her cusps are pointed upwards so that the straight line joining them is more or less approximately parallel to the horizontal plane, the fact is supposed to be an indication if not the cause of rain. If she submits to be "towed by one star and chased by another," that is, if she is between and near two conspicuous stars, so that the three bodies are at least nearly in a straight line, the fishermen expect a storm.

Though meteorologists show no favour to these and many similar beliefs, some of them admit that it is neither unphilosophical nor contrary to fact to regard the moon as a meteorological agent. Thus, Sir John Herschel, from his own observations, regards it as a meteorological fact that the clouds have a tendency to disappear under the full moon, and adds that a slight preponderance in respect of quantity of rain near the new moon over that which falls near the full, would be a natural and necessary consequence of a preponderance of a cloudless sky about the full.* M. Arago, who concurs in this opinion, states that the expression "the moon *eats the clouds*," is common in France among country people, and especially among sailors.† The latter philosopher adds that the résults obtained from meteorological observations in Germany and in Paris, were that the maximum number of rainy days occurred between the first quarter and full moon, and the minimum between the last

* 'Outlines of Astronomy,' par. 432, and note, p. 285. 5th edit. 1858.

† 'Popular Astronomy,' Smyth's Translation, vol. ii., ch. xxiii., pp. 311–313. 1858.

quarter and new moon; the ratios being 100 : 121·4 in Germany, and 100 : 126 in Paris; but that in the south of France the minimum number of rainy days occurred between the full moon and the last quarter. He concludes with the remark that "the question requires to be examined afresh."*

Having by me an unbroken series of carefully-made rainfall observations from the beginning of 1864 to the present time, I have tabulated the results below so as to show the amount of rain, the number of wet days, and the wet-day rate of rain in each of the four quarters of the seventy-four complete lunations, beginning with the new moon on January 9th, 1864, and ending with January 1st, 1870—a period of 2185 days.

The word "quarter," as used here, may be defined thus:—*The first quarter begins with the day of the new moon, and ends with the day immediately preceding that on which, according to the almanac, the moon reaches the first quarter, and so on for the others.*

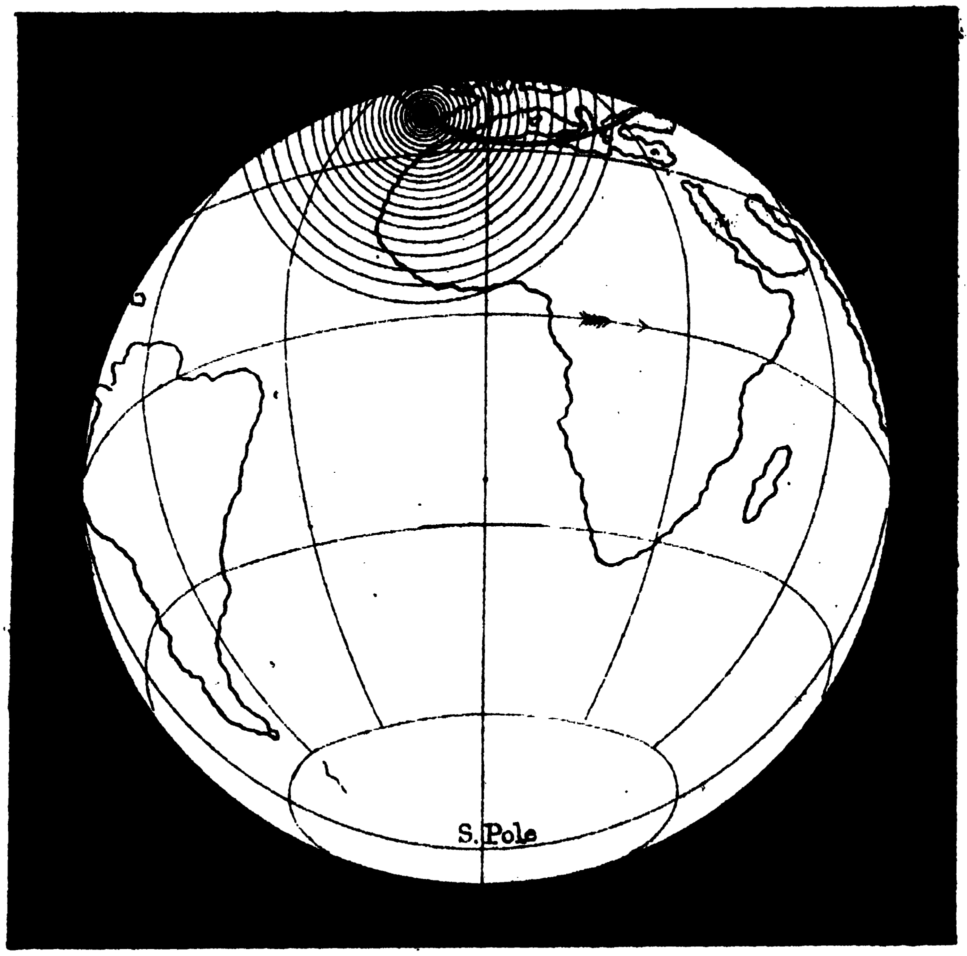
	Quarters.				Totals.
	First.	Second.	Third.	Fourth.	
Actual rainfall in inches	56·66	58·87	57·30	55·90	228·73
Relative rainfall	2477	2547	2505	2444	10000
Number of times rainfall was more than 25 per cent.	33	30†	34	30	..
Number of times rainfall was less than 25 per cent.	41	43†	40	44	..
Number of dry days	274	301	241	266	1082
Number of wet days	274	248	307	274	1103
Relative number of dry days	253	278	223	246	1000
Relative number of wet days	248	225	278	248	1000
Mean wet-day rate of rain in inches	·2141	·2374	·1866	·2043	·2073
Relative mean wet-day rate of rain	103	115	90	98	100

From the foregoing Table, it is obvious that with regard to the three pluvial elements, in South Devon, during the six years ending with January 1st, 1870, the four quarters of the seventy-four moons may be arranged, in descending order, as below:

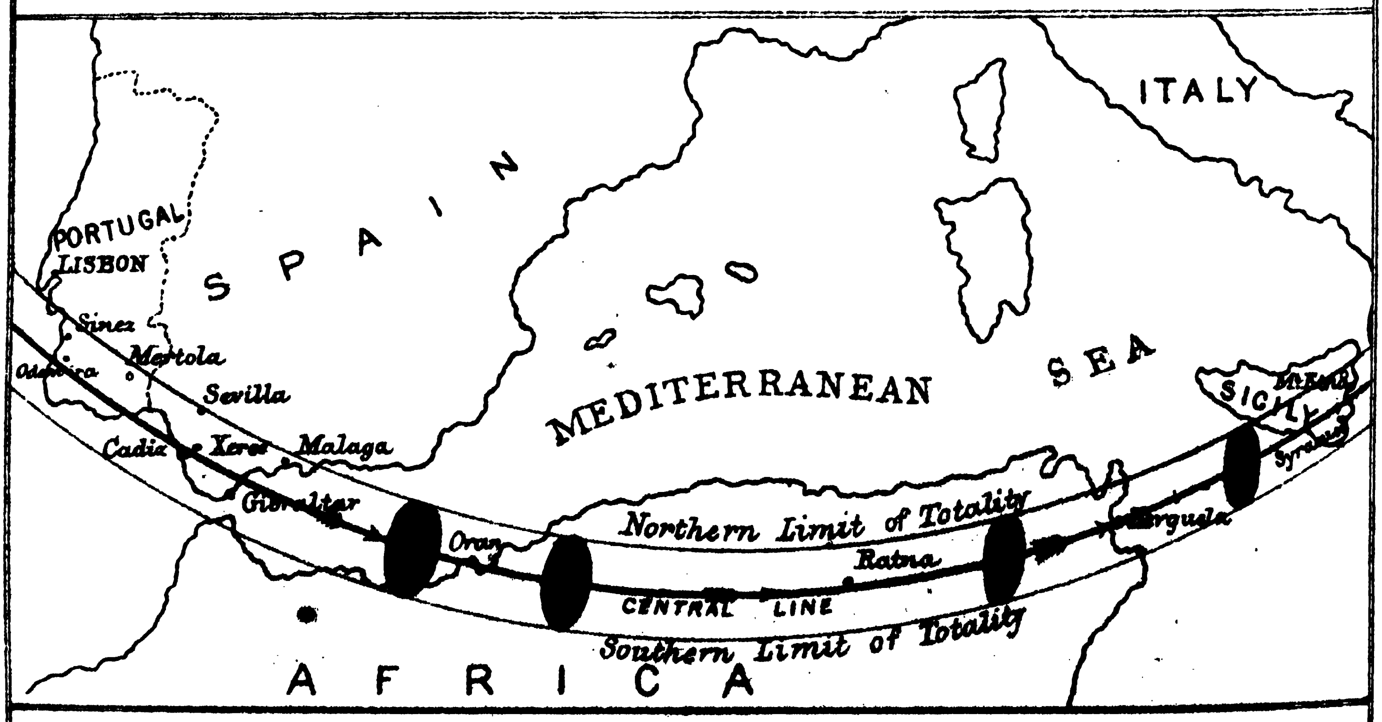
Rainfall.	Number of Wet Days.	Wet-day Rate of Rain.
Second. (greatest)	Third. (greatest)	Second. (greatest)
Third.	{Second.}	First.
First.	{Fourth.}	Fourth.
Fourth. (least)	First. (least)	Third. (least)

* 'Popular Astronomy,' Smyth's Translation, vol. ii., ch. xxxv., pp. 317, 318.

† The rainfall of one "second quarter" was exactly 25 per cent. of that of the lunation.



How the Earth is presented towards the Sun, during the Eclipse, and the path of the Moon's Shadow.



The course and shape of the Moon's Umbra.

Litho Whiteman & Bass, London.

This tabular summary shows:—

1st. That the quarters arrange themselves in an entirely different order under the different heads, with the single exception of the second being the quarter of greatest average rainfall and also of greatest average wet-day rate of rain.

2nd. That the least average rainfall was in the quarter immediately preceding the new moon, instead of being, as Sir J. Herschel supposes, about the full moon.

3rd. That the maximum number of wet days was in the third quarter, and the minimum in the first; thus differing in every particular from the results stated by M. Arago to have been obtained in Germany and Paris, on the one hand, and in the south of France on the other, which, as we have seen, differed from one another.

This discussion may be appropriately closed, perhaps, by echoing Arago's remark, that "the question requires to be examined afresh."

V. THE APPROACHING TOTAL SOLAR ECLIPSE.

By R. A Proctor, F.R.A.S., &c.

The eclipse of next December is less remarkable in many important respects than the two total solar eclipses now commonly known as the Indian and American eclipses of 1868 and 1869. The former of these was distinguished among all the eclipses of recent times by the exceptional extent to which the lunar disc overlapped, during central totality, the concealed disc of the sun. For more than six minutes at some stations no direct solar light was visible. The eclipse of last year was not distinguished in this particular way, though the duration of totality—at some stations exceeding four minutes—was far from inconsiderable. What rendered the American eclipse so extremely important, even more important than the Indian one, was the fact that a large proportion of the track of the moon's shadow lay across a region dotted over with well-armed observatories. It is probable that on no previous occasion has so large an array of practised observers been employed in scrutinizing the phenomena of a total eclipse; and it is absolutely certain that so many appliances had never before been employed to render the researches of the observers effective.

In both respects the approaching eclipse is less important. The greatest duration of total obscuration will be but 2 m. 11 s.; and the track of the moon's shadow only skirts the region within which the principal European observatories are situated. In fact, the only parts of Europe traversed by the shadow are the southern provinces of Spain and Portugal, Sicily, the southern extremity of Italy, and

parts of Greece and Turkey. And of these regions only those in the Spanish peninsula and Sicily are practically available, because in the others the duration of totality will be less and the sun will have but a small elevation. In Greece, for instance, and Turkey, though the phenomena of totality may chance to be well seen, yet the chance is not such as would justify an expedition from the principal astronomical centres of Europe. The best places of all for observing the eclipse will undoubtedly be those along or near the track of totality in Algeria. These, however, will probably be left to the astronomers of France.

Fig. 1 shows the actual presentation of the earth towards the sun, and the course and shape of the moon's shadow on December 22nd next. The hour is supposed to be solar noon at Greenwich. The earth must be conceived to be rotating in the direction shown by the arrow (on the equator), and at such a rate that any meridian line in the figure will reach the place occupied by the next meridian towards the right in two hours. The black spot to the west of Spain represents the shadow of the moon at the hour named. This shadow is surrounded by the penumbra, a portion of which, however, remains throughout the eclipse beyond the northern limits of the earth's disc. The course of the shadow is indicated by the curved line taken through the black spot. If an observer on the sun could trace the apparant path of the moon's centre across the earth's *disc*, he would not find it curved in this way, but appreciably straight. As the earth is rotating, however, the disc turned towards the sun undergoes an appreciable change during the duration of central eclipse, and the motion of the different points of the earth along parallels curved like those shown in the figure, causes the path of the moon's centre with reference to the earth's *globe* (distinguished here from her disc as seen from the sun) to have the shape indicated in the figure.

Central eclipse begins on the earth generally at twenty-six minutes before noon,—in other words the black shadow shown in the figure as already well advanced is supposed to have entered on the disc twenty-six minutes before the epoch corresponding to the figure. Central eclipse concludes for the earth generally at twenty-one minutes past one, or eighty-one minutes after the epoch corresponding to the figure. The total interval during which the moon's shadow (as distinguished from her penumbra) falls upon the earth is thus 1 h. 47 m.; and the amount of motion due (during this interval) to the earth's rotation can be conceived by remembering that the southern extremity of Spain moves during totality from a place below the dark spot in the figure (and on the proper parallel, of course) to about the place occupied in the figure by Sicily.

It will be evident from a further consideration of the relations

presented in Fig. 1, that there are two respects in which this eclipse is unfavourable. First of all, the track of the shadow lies far from the centre of the disc. It is clear that, *pro tanto*, the shadow is rendered smaller by falling near the outer parts of the disc; because these parts lie farther than the centre from the sun. Secondly, the elevation of the sun at the time of eclipse is not considerable. Since the sun is vertical at the place which occupies the centre of the earth's illuminated disc, and on the horizon for any place which lies on the circumference of that disc, it is obvious that when the track of the moon's shadow lies as in Fig. 1, the sun's elevation is relatively small during total obscuration. In the present eclipse, at the stations where the chief observing parties will be placed, the sun's elevation will be about 30 degrees, amply sufficient for ordinary observing purposes, but not altogether so great as might be desired for spectroscopic and polariscopic researches, and still less satisfactory for photography.

Fig. 2 presents on a larger scale the track of the moon's shadow, and the actual oval shape of the black spot which seen foreshortened in Fig. 1 appears as a circle. It will be seen that Odemira in Portugal, Cadiz and Xeres in Spain, Oran and Ratna in Africa, and Syracuse in Sicily, are the principal towns which lie very close to the central line. But it is probable that the stations will be selected without special reference to the proximity of towns; indeed for many purposes the less inhabited regions of a country are best suited for such observations as have to be made during eclipse.

Although Mount Etna is not very close to the central line, there are reasons for believing that a party stationed on the summit of this mountain would be enabled to make important observations. They would be more than twice as far raised above the sea-level as those observers were, who during the American eclipse obtained such favourable views of the solar corona from the summit of White Top Mountain. It will be remembered by our readers that General Myer reports the extension of the corona as seen from this station to have exceeded more than twofold the extension observed by those at lower levels. As there will probably be an English observing party near Syracuse, it would be a matter of the utmost interest and importance to compare their observations of the corona with those made at the summit of Etna.

At present, it may be mentioned in passing, there seems every reason to believe that two important expeditions will be sent from England to observe the eclipse. As we write, the arrangements are not complete, and there still remains a possibility that the whole undertaking may fall through. But it is hoped that this may not be the case, and that the large array of volunteers whose names appear in the list of the two proposed expeditions may be enabled to devote their energies to the work they have severally undertaken.

The main object of the astronomers of this and other countries will be to determine the nature of the corona. For this purpose, each of the English expeditions is to be divided into four parties. First, there will be the spectroscopists; secondly, the polariscopists; thirdly, the photographers; lastly, there are the general observers, who in our opinion are very far from forming the least important portion of the expedition.

The spectroscopic evidence obtained during the Indian and American eclipses is contradictory and unsatisfactory. Let it be remarked in passing, however, that it is not altogether so contradictory as has been asserted. The American observers appear to have been misled into the supposition that Major Tennant saw the ordinary solar spectrum—that is, that the Fraünhofer lines could be seen in the spectrum of the corona. And indeed in Prof. Roscoe's treatise 'On Spectrum Analysis,' it is stated that Major Tennant saw the ordinary solar spectrum, whereas "Professor Pickering, on the other hand, saw only a continuous spectrum." But Major Tennant's account expressly asserts that the spectrum he saw was continuous. He says, "*What I saw*" (the italics are his) "*was undoubtedly a continuous spectrum, and I saw no lines.* There may have been dark lines, of course, but with so faint a spectrum and the jaws of the slit wide apart, they might escape notice." Thus the continuous spectrum seen by some of the American observers is in perfect accordance with Major Tennant's observation. Indeed the mistake is rather fortunate than otherwise, because it led the American observers to search specially for dark lines such as they supposed Tennant to have seen; and, therefore, their failure to recognize any may be regarded as all but decisive of the matter.

Where Major Tennant's observations are *not* accordant with those made by the American observers, these latter observations are themselves wanting in accordance. For Professor Young saw three bright lines in the coronal spectrum, and Professor Harkness saw one bright line; whereas Professor Pickering, like Major Tennant in 1868, saw only a continuous spectrum. This discrepancy will, we may fairly trust, be cleared up during the approaching eclipse. It may perhaps be found that different parts of the corona give different spectra. It may be noticed, however, that the bright line seen by Harkness and the bright lines seen by Young were delicate objects, and would almost certainly have escaped notice had these observers used a much narrower or a much wider slit than they actually employed. Professor Harkness failed to see the line till he had slightly opened the slit; but he would probably have lost it equally had he widened the slit too much.* May not Major

* The total quantity of light from the bright lines would be increased by widening the slit; but the intrinsic brilliancy of the broadened bands would be no greater than before. On the other hand, the intrinsic brilliancy of the continuous background would be increased by the change.

Tennant have failed through such a course? He says, "thinking that want of light prevented my seeing the bright lines which I had fully expected to see on the lower strata of the corona, I opened the jaws of the slit." It is worth noticing that failure may arise from this very adjustment. Too narrow a slit is clearly unfavourable, because a certain quantity of light is required for distinct vision; but on the other hand too wide a slit is equally unfavourable, because a certain relative superiority in the brightness of the lines (or in this case *bands*) over the background of the continuous spectrum is equally requisite. The obvious conclusion is, that a telescope of large aperture and therefore of high light-gathering power should be employed, and the light of the continuous background reduced as much as possible by increasing the dispersion.

As respects the polariscopic operations, there is a similar contradiction to be explained during the approaching observations. The observers of the Indian eclipse assert positively that the light of the corona is polarized in a plane through the sun's centre; the American observers, on the other hand, as positively deny this. The Astronomer Royal (than whom no higher authority—on this particular subject—exists) solves the difficulty summarily by expressing his belief that the observers in India were not sufficiently familiar with the principles of polariscopic research to interpret what they saw. In this case, and assuming a similar state of things in the case of the American observers, we must look forward to the approaching eclipse as likely to supply the first really reliable information yet obtained respecting the polarization of the corona. We cannot doubt that the observers next December will not fail from want of knowledge, since not only has the Astronomer Royal called special attention to the necessity of their carefully preparing themselves beforehand, but the government of the party has been assigned to Professor Pritchard, who is nothing if not a master of the science of theoretical optics. Our great fear is, however, lest the methods of testing light at present in vogue may not be sufficiently effective for the resolution of the somewhat difficult problems depending on the polarization of the corona. Whatever advantage there may ordinarily be in the use of well-tried methods, it may be questioned whether in this particular case more powerful instruments than the polariscopes at present in use might not be devised and employed with advantage.

We pass over the photographic department of the expedition; in the first place because there is every reason to feel confidence that under the able supervision of Messrs. Browning and Brothers (at Gibraltar and Syracuse respectively) the photographic arrangements will be exceptionally successful, and in the second because as regards the inquiry, which is the main purpose of the expedition, photography can teach us comparatively little. Unless the whole

duration of totality were given to a single negative—which would be clearly unwise—no satisfactory picture of the corona could be obtained.

The chief promise of the expedition, in our opinion, lies in the number of skilled observers who have joined the two parties which are to devote their energies to general observation. The names of Mr. Lassell, Lieut.-Colonel Strange, and others (it is almost invidious to particularize), afford a sufficient guarantee not only of skilful observation, but also of a thoughtful study beforehand of the *modes* of observation likely to be most successful. We cannot suppose for a moment that such observers will be content merely to renew the observations which have been made so often and to such little purpose,—to tell us merely the oft-told tale respecting the beauty and splendour of the corona, its colour, extent, shape, and so on. Something much more definite is required, and that something, if it can be obtained (of which we have no doubt whatever), is surely to be expected from the skilful astronomers who have promised to take part in the general observations to be made on the corona.

Let us consider a few of those points on which it is most desirable that information should be obtained.

It has been observed by some astronomers that the structure of the corona seems in places to be marked by the presence of curves and striations, and sometimes even of complex portions, which have been compared to "hanks of thread in disorder." It is most important that adequate telescopic power should be applied to determine how far this appearance is real, and what peculiarities may be recognized in the curves, hanks, and striations, under telescopic scrutiny. For this purpose the disc of the moon ought not to occupy (as has been usually the case) the centre of a large field; but the brighter part of the corona close by the moon's limb should be kept altogether out of the field of view. Further, different powers should be employed, and the focussing for each should be very carefully noted. For even those who reject wholly (as we confess that we do) the theory that the corona is merely a phenomenon of the earth's atmosphere, must recognize the fact that the appearance of the corona may be, and probably is, very much affected by our atmosphere, through which it is necessarily seen. So that some of the peculiarities which apparently belong to the corona may in reality appertain to our own atmosphere. In this case the focussing suitable for clear recognition of the causes of such peculiarities would correspond to the relatively small distance of the upper parts of our atmosphere, and would thus differ appreciably from the focussing for celestial objects. It has been suggested that "the use of a telescope of low magnifying power but first-rate definition, a comet eye-piece being employed, would be desirable in

studying the corona. The telescope should be accurately driven by clockwork, and a dark iris-disc, if one may so describe an arrangement which would be the converse of an iris-diaphragm, might be employed with advantage to hide the light of the prominences and chromosphere. If the field of view were several degrees in diameter, and the dark disc at the beginning of totality concealed a circular space extending a degree or so beyond the eclipsed sun, the observer might first examine with great advantage the outer parts of the corona, and gradually extend his scrutiny to the very neighbourhood of the prominences."

A question of extreme importance, which seems fairly within the range of the available modes of research, consists in the determination whether the outer and extremely faint parts of the corona show any sign of prolongation towards those regions where, as we know, the zodiacal light extends. The whole of that portion of the heavens along which (speaking with reference to the place of the sun) the zodiacal light is ordinarily visible, is above the horizon during most total eclipses. Further, the dark region corresponding to the place occupied by the moon's shadow in our atmosphere, extends at the beginning and end of totality over a very wide range of sky, first on the western and then on the eastern side of the lunar disc. Along this region the faint glow of the zodiacal light ought to be perceptible if sought for under favourable circumstances. Among such circumstances are, of course, a clear sky and an elevated station. But there is one condition which, so far as we know, has never yet been attended to. The maximum darkness of a solar eclipse comes on so rapidly that the eye is yet dazzled by the light when totality is in progress. Nor does totality last long enough for the eye to acquire the power of recognizing faint differences of illumination. This fact serves to explain the failure of observers, hitherto, in detecting the delicate phenomenon we are now considering. There appears to be good reason for believing that the search would be conducted with a much better prospect of success if the observer who undertook it were in the first place to keep his eyes as much as possible in darkness until totality had fairly commenced; and in the second, to hide the whole of the corona from view while searching for the zodiacal light. This could be very easily managed by arranging beforehand a black disc so as to conceal the sun at the time of totality from an eye placed at a certain aperture, through which the observer should conduct his search, during totality, for the faint light along the ecliptic. This method seems so promising, and the inquiry itself is so full of interest, that we cannot but hope some observer will be willing to devote himself specially to this particular subject.

But we may safely expect from those who have volunteered to take part in an expedition which will probably be by no means a

pleasure trip (remembering the season and the nature of the voyage) the thoughtful consideration beforehand of all those means by which the expedition may be made successful. They will be fully aware that the astronomical world will expect from them something more than the renewal and confirmation of former observations. We may hope from them therefore results of extreme interest, throwing new light on important problems of solar physics, and perchance even revealing unexpected truths respecting the economy of the solar system itself.

VI. THE CONTROVERSY ON SPONTANEOUS GENERATION: WITH RECENT EXPERIMENTS.

By James Samuelson, Editor.

There is perhaps no biological question, excepting the origin of species, which has been so warmly debated in England and abroad, as the mode in which the lowest known types of animal and plant life come into existence, and probably one reason why these inquiries have been productive of so much excitement, is their indirect theological bearing.

The developmental theory recently elucidated by the researches and arguments of Darwin gave a fatal blow to the ancient beliefs concerning the first appearance and presence of the animal and plant races on the earth's surface, and rendered unnecessary the special intervention of the Creator to account for the production of new species; whilst the hypothesis of spontaneous generation, or the creation *de novo*, in organic infusions of the lowest known types of plants and animals in our time, seems, to impetuous and superficial thinkers, to put the divine influence altogether out of sight, and almost to degrade what have hitherto been regarded as living beings and vital forces to a level with the unconscious physical forces and inert forms of matter.

With these considerations, however, scientific men have no concern, and whether or not the creation of a living thing from organic or inorganic materials, by what may be termed artificial means, be regarded as a sacrilege, the investigation must be undertaken without apprehension or prejudice, and the verdict given, not by theology or theologians, but on the evidence of strict experimental research, and from unprejudiced inductive reasoning.

Scientific men being, as a rule, regarded as ruthless iconoclasts, anxious only to lacerate the feelings and undermine the most sacred aspirations of true believers, it may be supposed that these remarks are prefatory to an argument intended to overturn all our preconceived views as to the higher nature of life, and to hand over the

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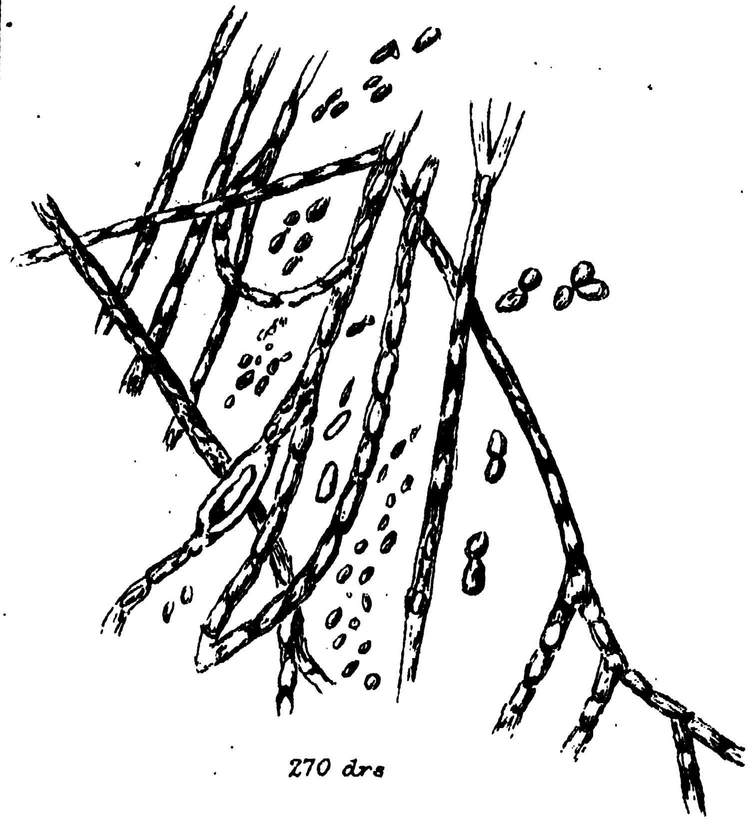


Fig. 2

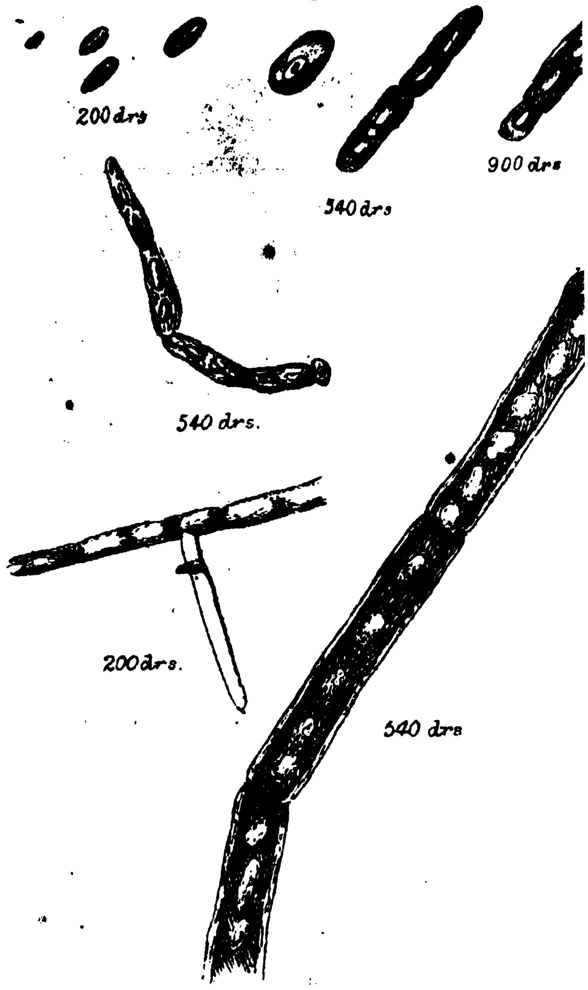


Fig. 4.

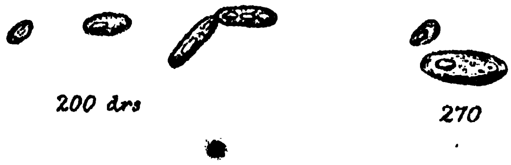


Fig. 3.

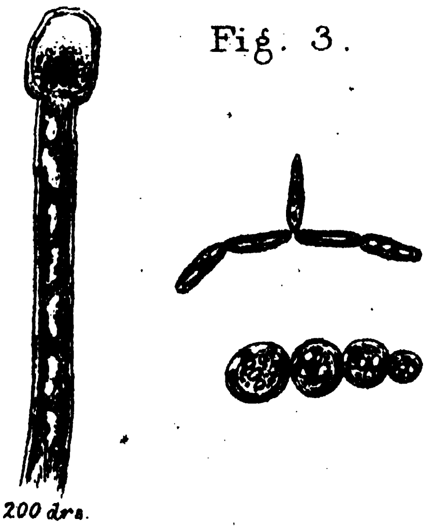
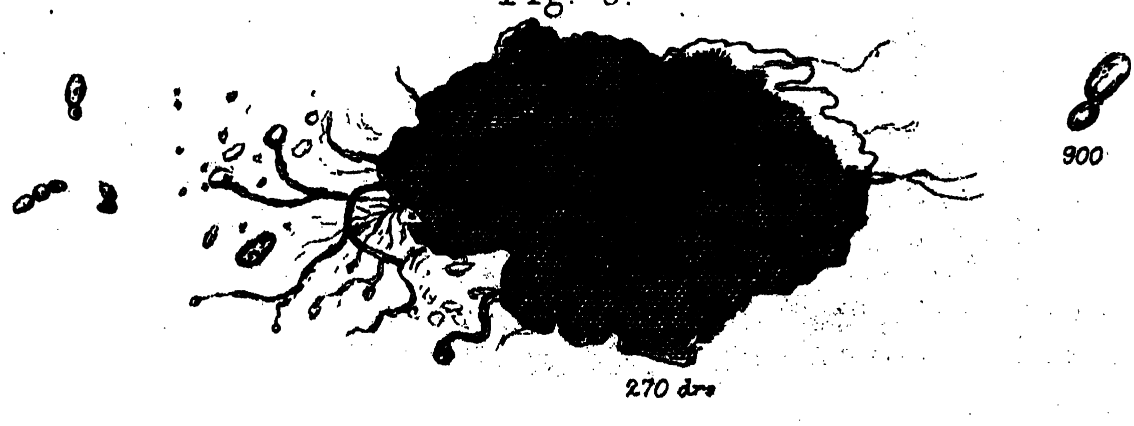


Fig. 5.



Litho. Whiteman & Bass, London

Organisms found in infusion of Orangejuice, and in pure Rain Water.

task of creating living beings to the chapter of accidents and to the blind physical forces of nature. My task is, however, not of such a painful character. In the first place, it must be remembered that if it should turn out that living beings are capable of springing into existence through the direct transformation of decaying organic matter, those beings are, so to speak, merely the instruments upon which the higher psychical faculties play; from dust they come and to dust they return. And again, every advanced thinker is prepared to admit that even the higher races which animate, beautify, or transform the earth's surface, are fed, grow, and decay through the direct operation of the physical forces, and that they are exquisitely constructed machines, liable to injury, accident, and destruction, and need fuel and reparation just as any humanly-constructed mechanism. What difference, then, can it make to any but the most timid or bigoted thinkers whether the first appearance of the lowest types of animal and plant life is due to the direct action of the physical forces upon matter which has once been organized and is undergoing decomposition, or to the same forces or some unknown modification of them acting in the first instance in or upon almost inconceivably minute pre-existing germs?

I can, however, offer to such timid philosophers the crumb of comfort, that it is not unlikely the ultimate result of the discussion which now agitates the scientific world will be to show that the lowest known living types are *not* now created *de novo*, but that their germs are almost omnipresent and ineradicable; and this conclusion has been arrived at by me, not from the experiments with varying and contradictory results which have been tried by different investigators, but from a calm consideration of the whole question, renewed at intervals, over a space of nearly fifteen years.

And this reflection causes me to draw attention to a peculiar circumstance connected with the controversy on spontaneous generation; namely, that we hardly ever hear of the work of any observer extending over a lengthened period. In most cases we have a set of experiments tried by an investigator of greater or less eminence now a zoologist, then a chemist, which are published along with his views, usually of a very decided and dogmatic character, and then he rushes out of the arena, and we hear nothing more of him on that subject. Of course he has settled the question to his own satisfaction and to the satisfaction of those who agree with him, and there is no need of further investigation until some new circumstance or some fresh set of experiments invalidates all previous evidence and raises up a new host of combatants and disciples on either side.

We are at present in the very thick of such an intellectual contest, and no doubt there are many true believers in heterogenesis who regard as conclusive the recently-published experiments and observations of Dr. Bastian which have startled the boldest thinkers and

some of the most profound biologists; but after bestowing upon them the careful consideration which they well deserve, and trying such experiments as seemed to me to throw light upon some of the mysterious appearances described by him, I have come to the conclusion that, so far as he is concerned, the argument stands just where it was, and that the question is likely to remain an open one for a long time to come.

Many will, no doubt, remember that some years since Professor Huxley, influenced by the astounding revelations of organic chemistry, and by the facility with which one form of organic matter after another was being synthetically produced by chemists in their laboratories, ventured on the bold speculation that *possibly* experimentalists might one day be able "to take inorganic matters such as carbonic acid, ammonia, water, and salines in any sort of inorganic combination, and be able to build them up into protein matter, and then that that protein matter ought to begin to live in an organic form;"* but Dr. Bastian believes that he has accomplished even more than this, that he has taken solutions of saline substances in proportions which he details most circumstantially, has exterminated in them all the germs which they might possibly be said to contain, and by excluding the atmosphere has prevented the entrance of new ones which might be said to be floating in that medium; and that, yet, after intervals varying from nine or ten to forty days there have been spontaneously produced in and from those substances, not particles of protoplasm as it was hinted possible by Professor Huxley, but truly organized plants and small ciliated infusoria.

But, in the first place, his own account of these experiments is often very vague. For example, he tells us† that he prepared a solution of crystallized white sugar, tartrate of ammonia, phosphate of ammonia, and phosphate of soda, which was boiled for twenty minutes and kept *in vacuo* nine days; and, to use his own words, "when examined microscopically a few monads and bacteria were found in the first drops of the liquid which had been poured out before the whole was shaken."

So far, after nine days' exposure he found only what has been seen by a score of observers over and over again, and cautious investigators, such as Dr. Child, Dr. Beale, and others (as I ventured years since to predict), have refused to admit many of these minute moving specks to be living organisms at all. But he goes on to say, "The remainder was then poured into a conical glass, and after having been allowed to stand for a time, the supernatant fluid was removed and the last few drops containing the sediment were

* 'On our Knowledge of the Causes of the Phenomena of Organic Nature;' being Six Lectures to Working Men. By Professor Huxley, F.R.S. London: R. Hardwicke.

† 'Nature,' July 7, pp. 195–6.

examined." It is to be regretted that we are not informed how long the fluid was allowed to stand exposed to the air, for although in the case under consideration the only result of the exposure was the appearance of many "bacteroid particles" (whatever that may mean—for a bacterium itself is the minutest speck perceptible to the eye with high microscopic powers), "and monads of different sizes exhibiting the most active movements," yet I will show presently, that when certain fresh infusions are exposed under favourable circumstances only for a few hours, they become filled with perfectly-organized plant forms in different stages of growth. In addition to those "bacteroid" particles and monads, Dr. Bastian also found "irregular-shaped particles" which were active, and the conclusion at which I am constrained to arrive, is that his enthusiasm in the cause of heterogenesis has led him, there at least, to confound the atomic motion of organic and inorganic particles with the movements of similar objects, of which it is always necessary to trace the growth and development before they can be safely pronounced to be the germs of infusoria or of lowly plants.

Let me, in passing, recommend those investigators who are reviving the experiments of Pouchet, Pasteur, Schulze, Joly, Musset, Wyman, and others, all of whom have failed to convince the scientific world, that they should not only examine their infusions, as heretofore, some *days* after they have been sealed up, but some hours afterwards, and I have reason to believe that the comparison will change their views as to the result of closing and preserving those infusions.

Again, some of Dr. Bastian's experiments are strikingly adverse to the hypothesis that the types observed and described were created *de novo*. In experiment No. 13, a solution of tartrate of ammonia and phosphate of soda, which had been kept twenty days *in vacuo*, was found to contain a fungus, &c., whilst another solution, which had been prepared in the same manner and at the same time, was opened on the thirty-fifth day, and "yielded no organisms of any kind;" but mark! when a third solution of the identical substances was so treated as to give free access to the air, and was examined on the thirty-eighth day, there was found what the observer calls "a spirally-twisted organism." It seems to me that it would hardly be possible to adduce more convincing evidence against heterogenesis and in favour of the atmospheric germ theory than is afforded by these results, and a very striking confirmation of this view is to be found in a circumstance which has recently been discovered in another quarter, affording evidence, all the more valuable, because it was not intended to influence this controversy. Mr. Wood, of Middlesbrough, in his efforts to preserve tartaric acid solutions in a state fit for chemical experiments, has found that whilst such a solution will, under ordinary circum-

stances, become mouldy, it will not undergo that change if previously boiled and filtered—but it must in fairness be added that he says, even if exposed to the air. Whether he means constantly exposed to the air, or only occasionally, I am unable to say. How such substances become mouldy will be seen presently, and it will be found to have a direct bearing on the argument.

Before proceeding to describe my own recent investigations, however, I desire to make one more reference to the published opinions of Dr. Bastian, to show how necessary it is to be cautious before we construe the microscopical appearances connected with this inquiry.

In speaking of the pellicle which appears on the surface of infusions, Dr. Bastian says,* "What Burdach named the proligerous pellicle of organic solutions, is made up of an aggregation of monads and bacteria in a transparent jelly-like stratum on the surface of the fluid. It constitutes at first a thin scum-like layer, and although the monads and bacteria entering into its composition are motionless, M. Pouchet and others were not warranted in assuming from this fact alone that they were dead. There is indeed good reason for believing to the contrary, since, as pointed out by Cohn, when any of these particles are set free from the broken edge of a pellicle, they always resume their movements. Motion, therefore, may simply be prevented by the presence of the transparent jelly-like material in which they are imbedded, although the particles may be undoubtedly living."

Under what circumstances the observers examined this so-called "proligerous pellicle," I am unable to say, and Dr. Bastian himself says, that owing to his observations being carried on in winter, he was not able to witness those changes observed by Pouchet; but he describes certain other changes in this pellicle on infusions which, according to his account, resulted in the development of unicellular organisms.

Now, with all deference to the eminent observers quoted by Dr. Bastian, I venture to say that the appearances referred to have no bearing whatever upon the controversy, inasmuch as they are by no means confined to infusions.

Long before I had heard the expression "proligerous pellicle," or was aware that this phenomenon was supposed by the advocates of heterogenesis to precede the creation, *de novo*, of living forms, I had myself observed a precisely similar appearance in pure distilled water exposed to the atmosphere. This was recorded at the time, as follows, in a paper read before Section D of the British Association in 1863:—

"Let me, however, briefly refer to the results of the exposure of distilled water only, in July, for that experiment has not been re-

* 'Nature,' June 30, p. 172.

peated with such satisfactory results. The glasses containing the water were so placed in a box divided by three partitions and covered with lids of blue, red, and yellow glass, that the panes intercepted all dust falling perpendicularly, and for several days very little dust reached the contained water. A deposit of dust had meanwhile accumulated on the panes of glass. Finding little or no life in the distilled water, I washed the dust from the glass lids into the respective vessels, and on the following day repeated the examination. As usual, I observed particles of silex and fragments of organic substances, and, with a low power, these seemed to be imbedded in a gelatinous film. I had placed the little glass vessels themselves under the instrument, and after pouring off the water, examined the deposit with a power of about fifty diameters. On covering the sediment with a thin glass, and bringing a higher power to bear, I found the gelatinous film to consist of motionless transparent monads or cells, and carefully restoring the contents of the vessels, pouring back the water, I left them until the following day. During the night and day, the cells or monads had become endowed with rapid motion, and an examination of the water showed it to be peopled with myriads of active moving germs."

Here, then, is another phenomenon supposed to be attendant upon the creation *de novo* of lowly organisms in infusions, which I had observed and recorded years since in pure distilled water exposed to atmospheric action.

And this brings me to my recent investigations, conducted during the months of June, July, and August last. As considerable doubt has been thrown upon the existence of germs in the atmosphere by certain observers, in their anxiety to prove the spontaneous production of the lowest plants and animals, I first repeated my former simple experiments with distilled water, and this time I used open saucers, small glass well-dishes (those used to hold ink), and even test tubes.

On the 21st June I first exposed two saucers of distilled water to the air, and two days afterwards I found it to contain a little sediment of dust. On examination with the microscope, a drop of the water presented the appearance so frequently described by me. There were fragments of silex, soot, and minute moving germs. The latter I shall not attempt to dignify with scientific names; suffice it to say that the contrast between their movements and the molecular motions of particles of organic and inorganic matter afforded sufficient proof of their being endowed with life. I then filled two test-tubes with portions of this water, closed the opening of one with a sheet of cotton-wool, and left the other exposed to the air. From the 23rd June to the 5th July the weather was cold and rainy, conditions very unfavourable for the development of living germs; but between the 5th and 7th July the temperature

had risen considerably, and I then examined the tubes. (It should be added that I had in the meantime added distilled water to that in the open tube to compensate for evaporation.)

The exposed water contained numerous zoospores, and unicellular forms. Some of these were quiescent and attached together in clusters; others in active motion. There were some small amœbæ, small particles of protoplasm, with elastic cell-walls, well known to micro-zoologists. In these, not only the characteristic changing prolongations were visible, but I clearly followed the rhythmical movements of the contractile vesicle. From the other tube, the cotton-wool appeared to have excluded the dust and germs—the former having collected on the cotton, for I found no organisms of any kind. It is right, however, to mention that cotton-wool does not permanently exclude the germs; and in another case, where the conditions of development were favourable (if the view be correct that they are conveyed by the atmosphere), it will be found that the substance referred to failed to exclude them.

As to my saucers of distilled water, on going to examine them I found the contents dried up, but a considerable quantity of dust remained. This I scraped together; retained it until my return from a journey on the 19th July, and then submitted it to the following process in the laboratory of my friend Mr. Tate, of Liverpool, aided by his assistant:—

First we heated the dry dust in an open tube to 480° C., and then, allowing it to cool, we heated it again to 280° C. It had then caked, and after loosening it with a wire we added distilled water, and boiled it for a few minutes. Then I closed the tube containing the liquid temporarily with a little stopper of cotton-wool.

The same evening, on examining the sediment with a power of 200 diameters, I observed many of the appearances described by investigators who have opened infusions after they have been kept *in vacuo* several days; some, for example, similar to those described by Dr. Bastian in his first experiment recorded in 'Nature' of July 7th. But I did not feel justified in attributing the movements of the particles to their being endowed with life.

I then divided the chief part of the water containing the dust into two tubes, closing one with cotton-wool and leaving the other exposed, and a little of it was left in an open wine-glass. The open tube I examined on the 22nd, 23rd, and 24th July. The temperature was very high—82° in the shade—and the development of the little *Cercomonas*, so frequently described by me in former years* was very rapid, so that on the 25th its movements were clearly traceable amongst other lowly types.

The water in the wine-glass was again dried up, but the effect

* 'Journal of Science,' vol. i., p. 607, and elsewhere.

of the high temperature was surprising, and two hours after I had added a little distilled water to the dust I found it to contain clearly-defined and active monads and other living types. I may here mention that the very warmth of the hand in which the slide is held will often render active and instinct with life little unicellular organisms which, on being first examined with the microscope, appear inanimate and motionless.

On the 28th and 29th July I again examined the tubes, opening the closed one on the latter day, and found that although the number of forms in that was much less than in the one that had been exposed, they were alike in character, and I showed to two astonished visitors who had never seen such appearances, active *amœbæ* in water taken from both tubes.

Here my experiments with pure distilled water terminated, and, so far, they are not only confirmatory of what had been observed and described by me many years since, but they satisfied me that the solid floating contents of the atmosphere may be submitted to an exceedingly high temperature in the dry as well as moist condition without exterminating the living germs; and that when distilled water is added and the sediment is examined, either immediately or after a few days' exposure, even if the air has been excluded, it exhibits most of the phenomena believed by the advocates of heterogenesis to be proper to infusions which have been boiled and kept *in vacuo*.

And now I have to describe a second set of experiments, which may perhaps serve to throw light upon the appearance of those fungi which are frequently found upon decaying substances in the form of mould or mildew, and which Dr. Bastian believes he has been instrumental in creating spontaneously in organic and inorganic infusions. Two announcements recently made by the advocates of heterogenesis influenced the direction taken by my investigations. One was the statement contained in Dr. Bastian's account of his experiment No. 5,* that he had discovered in an infusion of turnip *in vacuo* which had been hermetically sealed five days, a reticulated substance which he calls "Leptothrix' filaments. The other was the discovery by Mr. Wanklyn, the chemist, of sufficient albuminous matter in a pint of air to render it highly probable, from that circumstance alone, that the atmosphere is charged with living germs. Mr. Wanklyn strangely enough cites his discovery, triumphantly, as conclusive evidence of the absence of such germs, inasmuch as the quantity of albuminous matter was found to be very insignificant; but Dr. Beale, one of our most experienced microscopical observers, has expressed the view † that Mr. Wanklyn has found a volume of such matter, which, insignificant as it may appear, renders it highly probable that of the air tested by him "not a

* Reported in 'Nature,' July 7.

† 'Nature,' July 28, p. 255.

thimbleful could be taken without containing several" germs. Mr. Wanklyn's evidence certainly reads very much like that of a scientific witness for the defence in a case of murder, who seeks to show that the deed could not possibly have been committed upon a certain clean deal floor where it is said to have been perpetrated, inasmuch as he had carefully examined a square inch of the floor, and had only discovered the minutest spot of blood!

As to the "Leptothrix" which Dr. Bastian found in turnip-juice, I may mention in passing that it is considered by microscopic botanists to consist of the mycelial filaments of mildew fungi,* and I believe from my own investigations, to be described presently, that if he had followed the growth of his "Leptothrix" he would have found it to be one of those plants. Now these mildew fungi are found not only in and upon decaying organic matters, but also upon bare stones and rocks, where they cannot be created *de novo*, but must necessarily result from atmospheric spores moistened by showers of rain. Coupled with the two circumstances just mentioned, the account given by Dr. Angus Smith of his mode of testing atmospheric air opened out to me a new field of inquiry. Dr. Smith's system of washing the air is admitted to be tedious and imperfect, though it may be the best in the cases with which he deals; but it seemed to me that no better method could be devised for ascertaining the nature of those substances which are held in suspension in the atmosphere than the one which nature provides in the form of rain collected as it falls from the clouds.

Two circumstances are well established as regards falling rain. The first is that at the commencement of a shower after a long-continued drought the rain brings down much more organic and inorganic matter than later on; and secondly, that after a heavy shower the atmosphere is for some time comparatively free from such matters.

Then as regards the discovery of filaments in infusions, I had tried some experiments with infusions of orange-juice, orange-peel, apple-juice, and cabbage-juice, in distilled water, freely exposed to atmospheric influences, in 1862 and 1863, and when Dr. Bastian's observations were published I recollected having found such a mycelium in orange-juice, and having corresponded with Professor Hoffmann about it, but as he could throw no light upon the appearance of the mycelium and I was unable to account for it, I dropped the investigations. A record of these observations was however kept, and was discovered by me amongst some old papers whilst I was making the following experiments, and they will now be found of some service.

On the 4th of August, after a long continuance of intensely hot weather, we had a violent thunderstorm. I had been expecting

* 'Micrographic Dictionary' (Van Voorst), article "Leptothrix."

and preparing for this, and at once proceeded to catch the rain as it fell, and at the same time to prepare an infusion of filtered orange-juice *in pure distilled water.* This infusion I divided between two glass-wells, one of which I closed with cotton-wool, whilst the other was freely exposed to the atmosphere; and side by side with these I placed a tall champagne glass full of the rain-water which I had collected during the shower, and which contained numerous particles of dust.

None of these liquids showed any undoubted signs of life when I examined them with the microscope, before exposure. The infusion contained organic yellow particles; the rain-water organic particles, fragments of minerals, empty sheaths, empty cell-walls, and minute moving specks.

The very next day, however, August 5th, I was astonished to find in the open infusion of orange-juice the mycelium figured and described by Dr. Bastian as having been present in his infusion of turnips, or one closely resembling it; and in my infusion it was accompanied by innumerable minute unicellular oval organisms, the careful examination of which satisfied me beyond a doubt that they were an earlier stage of the thread-like filaments. Some of them were single, others were undergoing subdivision into two or more segments, whilst on the other hand some of the filaments were giving off cells exactly resembling the smaller detached ones.

During a long course of microscopical observation of biological changes, I never was so much astonished as on that occasion to find with what rapidity Nature (or that I may not be misunderstood—Nature's Ruler) brings back to active life the decomposing materials which have been its previous stronghold; and had I been led away by momentary impressions I could not have conceived it possible that the change had been produced in that case by any other process than heterogenesis, or the elevation of a portion of the organic infusion into organized types, without the auxiliary influence of pre-existing germs. But a little reflection reminded me that it is just these first surprises and impulses which lead men to disseminate erroneous views, as it was no doubt the extraordinary appearance of maggots and flies on some decaying carcase which gave rise to the idea of those insects being spontaneously generated there. I therefore contented myself with figuring the cells and the mycelium as they appeared under varying powers of the microscope on the day in question and the four following days (Figs. 1 and 2), and during that time the mycelium gradually developed into a true mould or mildew fungus, some of which floated on the surface. At the same time numerous ciliated infusoria made their appearance.

On the 9th August I opened the other glass-well containing the infusion, and found it covered in like manner with mildew. I

carefully removed a portion and delineated one of the dry full-grown filaments with a cluster of spores in its spore-case at the extremity (Fig. 3). Of course I was surprised to find the progress which had been made in this closed infusion, but on consideration it soon occurred to me that if on the one hand the ingress of the first germs was impeded by the cotton-wool, on the other, the same agency prevented their egress when they were produced there, and compelled them to fructify in the vessel in which they were confined; and moreover, whilst I had been daily disturbing the organizations in the open vessel, and adding distilled water to compensate for evaporation, the other had remained undisturbed during the whole period.

Then on examining, for the first time after exposure, the rain-water in the champagne glass, I there discovered large numbers of the same unicellular organisms as in the two infusions, some single, others undergoing subdivision, precisely as in the cases described (Fig. 4), and the natural inference to be drawn from this circumstance would be, of course, that the mildew fungi were the result, not of spontaneous generation, but of the introduction of germs from without. But here again it was necessary to exercise caution before coming to a conclusion. In the first place, the very fact which I have been trying to demonstrate, *viz.* the existence of innumerable atmospheric germs, at once suggested the probability that the germs in the rain-water which stood close to the infusions might have been wafted into it from the fungi growing in those infusions. And secondly, the slightest residuum in my dipping tubes, which I might not have cleansed properly, would suffice to account for the appearance of these cells. These doubts were partly cleared up at once.

On tasting the infusion which had been covered with cotton, I found signs of acid fermentation, and I examined drops from the surface as well as from the bottom of the liquid, for recent investigations on another subject had taught me that during such fermentation the biological phenomena vary in different parts of the fluid. At the bottom of the fluid I found clusters of large globular cells (Fig. 6), and on or near the surface groups of smaller elongated ones (Fig. 5). I was at once induced to compare these with the cells of the yeast fungus (*Torula cerivisiæ*) which are delineated in the 'Micrographic Dictionary,' and were said to have been found by the observer at the bottom and on the surface of fresh brewer's wort in which fermentation had just commenced. I could hardly find any difference between the two sets of cells, and in both cases those from the bottom of the fluid were round, whilst the surface cells were elongated. This is of course no proof of identity; and although I strongly suspected that in the one case as in the other the germs had been introduced from without, I

guarded myself from considering this as more than *prima facie* evidence. Another circumstance tended to show the correctness of this observation.

I had just found the notes of my experiments with infusions in 1863; and these entries had been made in connection with the infusion of orange-juice:—

"Aug. 3. Mycelium with minute cells."

"Like yeast-cells, 'Micr. Dict.,' Plate 20, Fig. 23."

"Aug. 7. The flocculent deposit tastes like mould." "No acid taste."

This description and the sketches which accompany it leave me in no doubt that the appearances were precisely those which I had observed last month, and the Plate and Fig. referred to in the 'Micrographic Dictionary' are strangely enough the same as I had a second time consulted after an interval of seven years, and which will be found copied in an article recently published by me on the manufacture of Beer.*

The same notes contained the following entries:—

1. In regard to an infusion of cabbage-juice exposed July 27th, and examined August 2nd—

"Homogeneous cellules.—Little or no motion, and nothing to indicate whether they were spontaneously produced from cabbage. *Closely resembled sessile monads in dust exposed under coloured glasses.* See paper before Academy" (des Sciences).

2. Concerning *pure distilled water* exposed August 2nd, 1863, examined 7th (temperature 70°)—

"*A little mycelium, same as in organic matters.*"

The only difficulty I experienced was this. It seemed to me incredible that the same specific germs which (as I believed) had floated in the atmosphere in 1863, and had then found their way into and had become developed in infusions of orange and cabbage juice as well as in distilled water, should again be present in an infusion of orange-juice and in distilled water in 1870, but a further investigation soon decided the matter.

On the 22nd of August last, again, after continued warm dry weather, the rain set in, and during the first hour I succeeded in catching some direct from the clouds in two distinct localities: at my own house, which is in Everton, at the very outskirts of Liverpool, with gardens about, and trees and fields close at hand; and also in Vauxhall Road, one of the most unhealthy of the lower parts of the town, where, notwithstanding the efforts of the sanitary authorities, the atmosphere is charged with smoke and other emanations from factory chimneys.

* "Beer:" see 'Journal of Science,' July, 1870.

On examining the rain which had fallen in both these localities I found, naturally enough, no animal or plant germs in that from the lower part of the town, although it was highly charged with soot and various kinds of dirt; but in that which had been collected near my house, I found on the same day a few of the unicellular organisms as before, some single, others undergoing sub-division; also a little soot and silex. On the following day I expected these germs would have sprouted, and I was not mistaken. I had cleansed my tubes well with sulphuric acid, after having made them red-hot, and had taken every possible precaution to avoid fusion of the fluids or their contents; but the result was unmistakable. The particles of soot and silex were present in the Vauxhall Road water, but no germs of any kind, nor any mycelium; whilst that caught in Everton was full of unicellular organisms in various stages of growth and sub-division, and the particles of soot had become beds, as it were, in which the germs were sprouting, for out of them grew fibrous filaments precisely resembling those which I had first observed in the infusions (Fig. 7). On the 24th (the following day) these filaments had assumed the form of a straggling mycelium, not so thick as in the former infusions, and not so much interlaced, but the identity of the organisms was quite undoubted. There were also swarms of minute rapidly-moving infusorial germs along with somewhat larger ciliated infusoria.

Coupling, then, my experiments of former years with those recently tried by me, the results, as far as they bear on this controversy, are as follows:—

In 1863. I found in infusions of orange and cabbage juice the germs and mycelium, which constitute the earlier stages of mildew fungi, and at the same time I found those lowly plant forms in pure distilled water which had been exposed to the atmosphere. Recently I again found this plant type in an infusion of orange-juice, and traced its growth into a mildew fungus. I also found it in pure distilled water, and afterwards, well developed, in rain-water caught as it fell direct from the clouds. This plant, or one closely allied to it, Dr. Bastian believes to have been spontaneously generated in an infusion of turnip-juice contained *in vacuo* in a closed tube.

Again in 1862–3. Dr. Balbiani in Paris, and I in Liverpool, found simultaneously in pure distilled water exposed to the atmosphere, and in dust taken from window-panes and elsewhere, various infusorial animalculæ, especially one well-defined type, which I have again recently found in pure distilled water, and in dust which had been submitted to a high temperature. And that such animal germs are present in the atmosphere in all parts of the world, I showed some years since, by submitting to microscopical observa-

tion the dust shaken from rags which had been picked up in the streets of Tunis, Trieste, Melbourne, Bombay, and other places from which such rags are imported. These animal types, too, are believed by some to be spontaneously created in infusions.

Here I leave to the judgment of men of science the results of my experiments, which any boy possessed of a microscope may repeat as effectually as I have performed them. And if the believers in spontaneous generation still insist that their hypothesis has not been refuted, and that, assuming my observations to be correct, their view of the case has not been fully disproved, I am not prepared to deny this; but on the other hand I must be permitted to retort that *their* experiments have only proved, so far, their inability, notwithstanding all their precautions, to exclude invisible germs from their infusions. As to the mysterious appearance of these microscopical types on their solutions *in vacuo*, what is it compared with the presence of some of the internal parasites of man and the lower animals? And who would have credited twenty years since, the story of the wanderings and metamorphoses which those forms undergo before they find their way into the final habitat designed for them by Nature? There is, however, very little chance of the controversy coming to an end at present. It is fascinating and exciting, and in so far quite in accordance with the spirit of the age. Nor is it desirable that it should cease, for it is causing microscopical observers to direct their attention more and more to the beginnings of life, and to the development of those living types which are visible only with the aid of the lens; and I know of no subject more worthy of the consideration of biologists.

VII. THE DEVONSHIRE ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, LITERATURE, AND ART.

Early in 1862, it occurred to a few scientific men, residents in Devonshire, that they might with advantage establish in their own county an institution resembling the British Association, of which they had for several years been more or less active members. The idea having been favourably received in some of the principal towns of the county, a meeting was held at Plymouth, which, though not largely attended, was thought to be of sufficient weight to inaugurate the proposed Association, to draw up a provisional constitution, to elect officers for the first year, and to announce that the first annual meeting would be held at Exeter on the 14th and 15th of August, 1862.

From that time, meetings have been annually held in different

towns of the county, the number of members and of papers have steadily increased, and several distinguished men have accepted the office of President. In short, the Association is not only well established in the county, but it is also fully and cordially recognized by the scientific world generally.

We proceed to give a brief sketch of its history, constitution, and operations, believing that there would be little or no difficulty, and very great advantage, in establishing kindred institutions in the other counties of the kingdom.

Being limited to a single county, it was decided not to restrict it to science. It was accordingly named "The Devonshire Association for the Advancement of Science, Literature, and Art," and its objects were declared to be "To give a stronger impulse and a more systematic direction to scientific inquiry in Devonshire; and to promote the intercourse of those who cultivate science, literature, or art, in different parts of the county." There can be no doubt that this decision was wise, as it was calculated to enlist a greater number of members, and to secure more numerous and a greater variety of papers, whilst it enabled men who might otherwise regard themselves as unqualified, to accept the office of President.

The number of members has steadily increased from 69 in 1862 to little short of 300 at present; and almost every part of the county is represented by them.

Each member pays ten shillings annually, or a life composition of five pounds, and is entitled to tickets of admission for himself and a lady, as well as to a copy of the annual 'Transactions.' Not only has this small sum been found sufficient to cover all expenses, but at the meeting held on July 26th, 27th, and 28th, of the present year (1870), under the presidency of Mr. J. A. Froude, the eminent historian, the treasurer reported a balance in hand of upwards of ninety pounds, besides property, in the form of 'Transactions' in stock, to the amount of upwards of one hundred and sixty pounds.

As the Association was not established for the purpose of accumulating money, there is reason to hope that it may very shortly be in a position to vote small sums for the purpose of conducting or aiding researches within the county. Devonshire, it is well known, is rich in bone caverns and barrows which would well repay investigation, and its moorlands abound in megalithic structures, of which at least accurate models should be made and placed in the museums at Exeter, Plymouth, Torquay, and Barnstaple.

The Presidents are ineligible for re-election. The following is the entire list, as well as of the dates and places of meeting, from the beginning:—

Dates.	Places.	Presidents.
1862, August 14th	Exeter	Sir J. Bowring, LL.D., F.R.S.
1863, July 29th	Plymouth ..	Mr. C. Spence Bate, F.R.S., F.L.S.
1864, July 20th	Torquay ..	Mr. E. Vivian, M.A.
1865, June 28th	Tiverton ..	Prof. Daubeny, M.D., F.R.S.
1866, August 8th	Tavistock ..	Earl Russell, K.G., F.R.S.
1867, July 23rd	Barnstaple ..	Mr. W. Pengelly, F.R.S., F.G.S.
1868, July 28th	Honiton ..	Sir J. D. Coleridge, M.A., Q.C.
1869, July 20th	Dartmouth ..	Mr. G. P. Bidder, C.E.
1870, July 26th	Devonport ..	Mr. J. A. Froude, M.A.

The earlier part of the first day of each annual meeting is devoted to business, and in the evening the President delivers his address, and thus "reads himself in." The next day is occupied, from eleven to four o'clock, with papers and the discussions they originate; and in the evening the members dine together. The third day is also devoted to papers, and the meeting closes about five o'clock.

During the first five years the papers were disposed of in one day, but since 1866 they have been so numerous as to furnish full employment for the second day, and it is now understood that the meeting will last three days.

During the nine years a total of 152 papers have been read, which may be classified thus:—

Geology and Palæontology ..	40	Literature	4
Archæology and History ..	35	Architecture	2
Botany and Zoology	23	Art	2
Meteorology	13	Engineering	2
Economic Science	12	Mental Philosophy	2
Physics	10	Biography	1
Education	6		

The Association claims "the right, at its discretion, of printing *in extenso* in its 'Transactions' all papers read at the annual meeting," and this right has been exercised ever since the first year, when abstracts only of the papers were printed. The copyright of the papers, however, remains the property of the authors.

One of the laws provides that the Association shall, within three months after each annual meeting, publish its 'Transactions,' including the Rules, a Financial Statement, a List of the Members, Obituary Notices of all Members who have died during the year, the Report of the Council, the President's Address, and such papers, in abstract or *in extenso*, read at the annual meeting, as shall be decided by the Council. The annual volumes are accordingly in the hands of the members within the stipulated time.

The 'Transactions' for the first year was a pamphlet of fifty-four pages, whilst that for 1869—the last which has yet been

printed—was a portly octavo volume of 537 pages. Up to this time the annual issues form three goodly volumes; and the first part of the fourth volume, or the fourth volume complete, according to the quantity of matter, will be printed before the end of October. They contain a vast amount of information respecting the county of Devon, together with matter of a more general nature.

Every author receives gratuitously twenty-five reprints of his paper, and may arrange with the printer for any greater number.

The next annual meeting will be held at Bideford, commencing August 2nd, 1871, when the Rev. Canon Kingsley will be the President.

The inhabitants of the towns in which the meetings have been held have always given the Association a cordial welcome. A large amount of both public and private hospitality has been displayed, a conversazione has commonly occupied one of the evenings, and the day after the close of the meeting has usually been spent in some picnic or fête.

It may be stated, in conclusion, that the Devonshire Association originated with men who were and still are members of the British Association, and whose active work for the offspring has not caused them to work a whit the less for the parent.

NOTICES OF SCIENTIFIC WORKS.

Researches on Diamagnetism and Magne-crystallic Action, including the Question of Diamagnetic Polarity. By JOHN TYNDALL, LL.D., F.R.S., Professor of Natural Philosophy in the Royal Institution. London: Longmans, 1870.

THIS work is the first instalment of a complete collection of the original memoirs on experimental physics, which the learned author has published during the last eighteen years. It contains not only a record of his own work on the subject of diamagnetism, but also extracts from the writings of Faraday, Plucker, Becquerel, Matteucci, Weber, and other experimental philosophers, bearing upon the same phenomena, so that the reader has before him everything necessary for a complete understanding of this very intricate subject. The second part of the book contains letters, essays, and reviews, relating to magnetism and electricity, and includes among others a discussion on the existence of a magnetic medium in space, the relation between magnetism and the electric current, an account of the polymagnet, and one of the clearest descriptions of Ohm's theory which we have ever read.

We are so accustomed to see a magnetic substance like iron or a magnetic needle point north and south, rush to the poles of a magnet when brought near to one, or arrange itself axially when suspended between the poles, that it is difficult to imagine that the vast majority of substances possess almost diametrically opposite qualities. When brought near to a magnet of sufficient power they are repelled from it, and when suspended freely between its poles they swing round, if of an elongated form, and arrange themselves equatorially or at right angles to the line joining the two poles, apparently with the object of getting as far away from them as possible. This action was named by Faraday "*Diamagnetism,*" the common phenomena exhibited by iron being named "*Paramagnetism,*" whilst *Magnetism* is used as a general term to include the whole range of both phenomena. Paramagnetic bodies are few in number, but they include some of extraordinary energy, iron, nickel, cobalt, and oxygen for instance; whilst diamagnetic bodies include the greater number of the metals, and such substances as rock crystal, heavy spar, sulphate of magnesia, marble, alum, common salt, saltpetre, carbonate of soda, Iceland spar, tartaric acid, citric acid, water, alcohol, ether, the mineral acids, glass, iodine, phosphorus, sulphur, resin, spermaceti, sealing-wax, turpentine, india-rubber, sugar, starch, gum arabic, wood, fresh beef, blood, apple, bread, &c. In fact, could a marble statue, or its living prototype,

be suspended between the poles of a sufficiently powerful magnet it would set equatorially, or east and west instead of north and south. Of all diamagnetic bodies bismuth has attracted the most attention, owing to the comparative power which it exhibits. Its diamagnetic properties, although vastly inferior to the paramagnetism of iron, are yet sufficiently marked to enable its properties to be observed with small permanent magnets weighing a few ounces; whilst a bismuth needle freely suspended will set itself parallel to the wires of a galvanometer. The property is not one possessed permanently by the bismuth, but is simply induced by the proximity of the magnet, nothing being communicated which the bismuth can carry away.

Having shown almost complete antithesis between the magnetism of iron and bismuth, the question naturally arose, Is this extended to polarity? Faraday worked long and earnestly at this question, and we believe to the last he was not satisfied that the question of polarity in diamagnetic bodies was settled, although the experiments with Weber's exquisitely beautiful apparatus were tried in his presence by Professor Tyndall. In a letter to Matteucci, dated November 2, 1855, Faraday wrote, "All Tyndall's results are to me simple consequences of the tendency of paramagnetic bodies to go from weaker to stronger places of action, and of diamagnetic bodies to go from stronger to weaker places of action, combined with the true polarity or direction of the lines of force in the places of action." On the other hand, it would appear as if these two philosophers were looking at the subject from entirely different points of view. Faraday had his mind fixed on lines of magnetic force, the use of which, as true representations of nature, he said never failed him; whilst Tyndall limited his view to that doubleness of action in which the term polarity originated. But these were apparent differences only, not differences in reality, for in the letter just quoted, Faraday said, "I differ from Tyndall a good deal in phrases, but when I talk with him I do not find that we differ in facts. That phrase polarity in its present undefined state is a great mystifier."

Considerable space is given to the description of the beautiful instrument devised by M. Weber in order to submit this question to a crucial test, the design of which was ably carried out by M. Leyser, of Leipzig. Clear engravings of it are given, and the experiments are described in full detail. With it not only has diamagnetic polarity been proved to exist in the case of bismuth, but the same result was obtained with cylinders of calcareous spar, statuary marble, phosphorus, sulphur, heavy glass, distilled water, bisulphide of carbon, and other non-conductors of electricity, removing the scruples of those who saw in the first experiments of this sort an action produced by induced currents. By these experiments,

Professor Tyndall concludes that a body of evidence has accumulated in favour of diamagnetic polarity, which places it among the most firmly-established truths of science.

This being the case, it would be of interest to ascertain on which side exists the fallacy of reasoning by which Professor Thompson has reduced the existence of diamagnetic polarity to an apparent absurdity; the paradox is well stated in the following quotation from a paper by Faraday, "On some Points of Magnetic Philosophy," published in the 'Philosophical Magazine' for February, 1855:—"If a globe of bismuth be placed without friction in the middle of the magnetic field, it will not point or move because of its shape; but if it have reverse polarity, it will be in a state of unstable equilibrium; and if time be an element, then the ball, being once moved on its axis ever so little, would then have its polarity inclined to the magnetic axis, and would go on revolving for ever, producing a perpetual motion. I do not see how this consequence can be avoided, and therefore cannot admit the principles on which it rests. The idea of a perpetual motion produced by static forces is philosophically illogical and impossible, and so I think is the polarity opposed or adverse static condition to which I have already referred."

Of course if time does not enter as an element in diamagnetic induction the above argument falls to the ground; but it appears to be so firmly established a fact that an exertion of physical force occupies *time*, that it can scarcely be doubted that it is concerned here also; that was Faraday's opinion, although he admitted that it seemed to be so brief in period as to be inappreciable by the means he had employed.

We should have liked to give an extended notice of the second subject included in the title of this work, namely, Magne-crystallic action,—the phenomena of which were at first so paradoxical as to baffle the ingenuity of the most acute experimentalists, but, thanks to the labour of Professor Tyndall and other physicists, now deducible with as much care and certainty from the action of polar forces as the precession of the equinoxes is from the force of gravitation. In the author's language, "The whole domain of magne-crystallic action is thus transferred from a region of mechanical enigmas to one in which our knowledge is as clear and sure as it is regarding the most elementary phenomena of magnetic action."

The magne-crystallic force is one by which certain crystals are caused to set themselves with certain of their axes parallel or transverse to the lines of magnetic force acting on them. This force acts at a distance, and is by no means so weak as might be at first supposed, for just as a crystal is moved by the magnet at a distance, so can the crystal also move the magnet at a distance. Faraday obtained the latter result by converting a steel bodkin into a magnet

and suspending it freely in the neighbourhood of the crystal. The tendency of the needle was always to place itself parallel to the magne-crystallic axis.

Neither will space permit us to refer, except in the briefest manner, to the results obtained by preparing bars of magnetic and diamagnetic substances, by reducing them to fine powder, and then compressing them in moulds in such a manner that the line of greatest compression is in different directions along or across the bar. A bismuth bar so prepared, squeezed flat within the jaws of a vice and suspended between the poles, will turn with the energy of a magnetic substance into the axial position; whilst a bar made up of powdered carbonate of iron (magnetic) compressed in this manner will recoil from the poles as if violently repelled. It thus appears that the line of magnetic action has a near relation to that of the closest contact among the material particles, and this relationship is traced in many different ways, and appears related to the cleavage of crystals.

It would be of interest to try some of these experiments on diamagnetism with the metal Thallium, a metal which, whilst it rivals, if it does not surpass, bismuth in diamagnetic energy, is as soft and amorphous as lead, and lends itself with the same facility to moulding and compression. Probably many of the apparent anomalies of diamagnetism which observers at first encounter, owing to the highly crystalline nature of bismuth, would disappear if thallium were the metal selected for experiment.

We cannot close this book without expressing the profound admiration which it leaves in the mind for the author's philosophical acumen and experimental skill. He moreover possesses one valuable quality, which we regret to say is as rare amongst scientific men as the combination of the two former,—that of placing his views and describing his experiments in such clear language that the profoundest mysteries of nature seem under his treatment to become clear and simple to a child's comprehension. Speaking as one who never loses an opportunity of listening to this philosopher on whom the mantle of Faraday has so worthily descended, the writer scarcely knows which gives him greater pleasure—to listen to one of Dr. Tyndall's lucid expositions of some hitherto hidden mystery of nature, or to hear him in his clear logical manner quietly put down a scientific opponent who has ventured to differ from some of his conclusions.

ON SAVAGES.*

WHAT Sir Charles Lyell has accomplished for the student of Geology, Sir John Lubbock is now achieving for the student of Ethnology. His 'Pre-historic Times'† first excited and awakened public attention by the clearness of its descriptions and the able and masterly manner in which the author dealt with the questions relating to primitive man.

In the present work Sir John Lubbock has adopted the same inductive method of reasoning which has been so ably applied to geological investigations by the illustrious Lyell in his 'Principles,' *viz.* that of explaining the monuments of the earth's past history by the "living present." Thus, from the habits and customs of modern savages we are enabled to understand the meaning and uses of the various relics of early man met with in civilized countries where no primitive races now exist, and we can thus more accurately picture and more vividly conceive the manners and customs of our ancestors in bygone ages.

Founded upon a course of lectures, originally delivered at the Royal Institution in 1868, the author proposes in the present volume "more particularly to describe the social and mental condition of savages, their art, their systems of marriage and of relationship, their religions, language, moral character, and laws." Sir John promises in a future volume to publish those portions of his lectures which have reference to their houses, dress, boats, arms, implements, &c.

"The study of the lower races of man," writes the author, "apart from the direct importance which it possesses in an empire like ours, is of great interest from three points of view. In the first place, the condition and habits of existing savages resemble in many ways, though not in all, those of our own ancestors in a period now long gone by; in the second, they illustrate much of what is passing among ourselves, many customs which have evidently no relation to present circumstances, and even some ideas which are rooted in our minds, as fossils are imbedded in the soil; and thirdly, we can even, by means of them, penetrate some of that mist which separates the present from the future."

On the subject of savage intellect, it seems difficult to realize the extreme mental inferiority of the lower aborigines; the mind of the savage, like that of the child, is of wonderfully small capacity and limited in its powers of taking in ideas; it is easily fatigued by exercise, and is generally in a dormant state. Curious instances

* 'The Origin of Civilization, and the Primitive Condition of Man' (Mental and Social Condition of Savages). By Sir John Lubbock, Bart., M.P., F.R.S., &c. 8vo. Pp. 380. London, 1870. Longmans and Co.

† Originally published (in part) in the 'Natural History Review.'

of this are mentioned from the accounts of various travellers; indeed, the number of authorities quoted under each chapter is truly surprising. No fewer than 178 authors and upwards of 200 works have been consulted and are referred to in these pages, the author in every case being cited, and credited with the statement made on his authority.

The cosmopolitan character of some customs has induced a strong belief in the unity of origin of the races among which such practices prevail; for example, among many races a woman is absolutely forbidden to speak to her son-in-law. Another curious custom is that known in Bearn under the name of "La Couvade." It would seem to be a very wide-spread custom for the father, upon the birth of a child, to be put to bed instead of the mother. The ideas among savages respecting the influence of food are equally ludicrous. Thus the Malays give a large price for the flesh of the tiger, not because they like it, but because they believe that the man who eats tiger acquires the sagacity as well as the courage of that animal. For the same reason the New Zealand baby at its baptism is made to swallow pebbles, so that its heart might be hard and incapable of pity. The reflexion of many of these ideas still linger with children and uneducated persons. A little girl was heard to say to her brother, "If you eat so much goose you will be quite silly." To take the portrait of a native is looked upon as most injurious, and the better the portrait the worse for the sitter; so much life could not be put into the copy except at the expense of the original. Pictures are also considered as efficient charms. Writing is believed to be even more magical than drawing.

Mungo Park on one occasion profited by this idea; a Bambarran offered him a supper of rice if he would write him a charm on his writing-board, to protect him from wicked men. The proposal was at once accepted. Park wrote the board full from top to bottom on both sides. The Bambarran, in order to secure the full force of the charm, washed the writing from the board into a calabash with a little water, and having said a few prayers over it, drank the powerful draught; after which, lest a single word should escape, he licked the board until it was quite dry.

The science of medicine, indeed, like that of astronomy, and like religion, takes among savages very much the character of witchcraft. Many savages do not believe in disease or natural death, but if a man die, however old, they conclude that he must have been the victim of magic.

Twins are considered as a bad omen, and in most cases one, in some others both are killed.

The belief in the attributes of life appertaining to inanimate objects is also very wide-spread.

A hook that has once caught a big fish is preferred to twenty

that have never been tried. Two fish-nets are never put together, for fear they should be jealous. The story of the natives of Tahiti who sowed some iron nails given them by Captain Cook, hoping thus to obtain young ones, reminds the writer of the story of a little boy of his own family, who planted his hair in his garden expecting it would bring forth a crop of little boys like himself. The ability or inability to draw seems to vary in one and the same tribe of aborigines; the absence of perspective is also very general, and extends to many people otherwise in a highly advanced state of civilization, such as the Egyptians, Assyrians, and the modern Chinese.

The earliest traces of art yet discovered belong to the Stone age—to a time so early that the Reindeer was abundant in the south of France, and that probably, though on this point there is some doubt, even the Mammoth had not entirely disappeared. These works of art are sometimes sculptures, if one may say so, and sometimes drawings or etchings made on bone or horn with the point of a flint.

The Esquimaux etchings of the present day appear to approach most nearly to these early relics from the caves of France, but they lack the spirited style of execution of the latter.

Upon the marriage rites, if such they may be called, much information is collected, but, as the author truly observes, many of the facts which he has recorded are very repugnant to our feelings, although it was impossible not to mention them in such a work. Marriage by capture appears to be very general all over the world, and where not attended by real violence the pretence of using force and even blows is kept up in form. The practice of carrying off the bride to the woods may yet linger among civilized nations, as, for example, in our own custom of the wedding tour.

The position of women among savage nations generally is very deplorable, nor can any amount of romance render savage life otherwise than revolting to an educated and civilized man.

Notwithstanding our advanced state of civilization, it is impossible, however, to deny the fact that—

"In many of our ideas and tastes we are still influenced by the condition of our ancestors in bygone ages."

"What that condition was," says the author, "I have in this work endeavoured to indicate, believing as I do that the earlier mental stages through which the human race has passed are illustrated by the condition of existing or recent savages. The history of the human race has, I feel satisfied, on the whole been one of progress. I do not of course mean to say that every race is necessarily advancing: on the contrary, most of the lower ones are almost stationary; and there are, no doubt, cases in which nations have fallen back; but it seems an almost invariable rule that such

races are dying out, while those that are stationary in condition are stationary in numbers also; on the other hand, improving nations increase in numbers, so that they always encroach on less progressive races."

It would be impossible in this brief notice to convey a very adequate idea to the reader of the mass of well-arranged facts upon which Sir John Lubbock has established his conclusions, but we give them in his own words.

"The facts and arguments mentioned in this work afford, I think, strong grounds for the following conclusions, *viz.*:—

> "That existing savages are not the descendants of civilized ancestors;
>
> "That the primitive condition of man was one of utter barbarism;
>
> "That from this condition several races have independently raised themselves."

Sir John Lubbock thinks we shall not be the less inclined to adopt these conclusions on account of the cheering prospects which they hold out for the future.

We heartily thank the author for his interesting book, which has afforded us not only much instruction, but also much real amusement in its perusal.

THE SCIENCE OF BUILDING.*

THE science of building is so comprehensive, and has been treated by so many able writers, that we must be prepared for some disappointment when perusing a work whose title would lead us to believe that the whole subject is included in its pages.

Since the application of iron to building purposes, a new study has presented itself to the architect, and Mr. Tarn's book contains many formulæ with which those who belong to his profession would do well to make themselves acquainted; for it is not uncommon to find such errors committed by them, as the loading of cast-iron girders to their full breaking weight, or a waste of metal in making them stronger than is necessary.

Whilst we commend the work to persons entering the building trade, we consider it right to mention that the study of mechanics, such as may be followed with the aid of 'Tate's Exercises in Mechanics,' would be even more useful to builders than Mr. Tarn's book, as it would sooner make them acquainted with the elements

* 'The Science of Building: an Elementary Treatise on the Principles of Construction.' By E. Wyndham Tarn, M.A., Land Architect. Lockwood and Co.

of mechanics which are indispensable to all who follow the profession.

In the chapter on retaining walls, the author should have directed the student's attention to the various methods of constructing them, and should have explained the difference between a vertical wall having its beds horizontal or perpendicular to its face, and one with an inclined face, and the transverse section of joint, perpendicular to that face. Also, in a brick retaining wall some advantage would be derived from the disposal of the length of brick or style of bond, and to the architectural student those are matters of great importance, for in many cases practice seems to defy theory. The author does not extend his chapters to the relative strength of brickwork, nor to an account of the various kinds of bricks made throughout England; details which are now essential in such a work, as bricks rank in these days amongst the most important materials of construction. His chapter on arches might also with advantage have been extended to the flat soffit and head or cambre arch, showing the limit of span for a given depth and breadth of face and soffit; also to observations on the groin arch, which would have imparted originality to his work.

The remarks on mortar and cement are limited, and it would have been well to refer to their tenacity and resistance to compression, their suitability for various situations; and the advantage of the application of concrete to bad foundations.

The information on centering of arches is also too much restricted and too indefinite. The pressure of the voussöirs in a pointed arch could not act on the centre at any of the angles in the manner named by the author, and it would have been better had he named the description of arch to which his remarks have reference, as the pressure of the voussöirs differs considerably in elliptic, pointed, and semi- or segmented arches.

The chapter on iron does not refer to the segmental or curved girder which is applied with much advantage in engineering, in railway and other works. There is also room in the chapter for observations on the trussed girder and the advantage or disadvantage of applying wrought-iron flitch-plates to wood beams. All these matters should have been referred to, so that the student of the 'Science of Building' (a title by the way which is likely to mislead those who purchase it into the belief that it is an advanced treatise) might be prevented from committing many errors into which architects and builders are too prone to fall.

CHRONICLES OF SCIENCE,

Including the Proceedings of Learned Societies at Home and Abroad; and Notices of Recent Scientific Literature.

1. AGRICULTURE.

The drought of 1870, though not so utterly destructive of succulent growth during the summer season as that of 1868, has been more injurious on the whole. Beginning earlier and ending later, it has spoiled both the hay crop and the aftermath; and the wheat crop too, generally so able to withstand a dry summer, has materially suffered. The returns from the correspondents of the 'Agricultural Gazette' declare the wheat crop to be below an average; and all other grain crops, except barley throughout Scotland, and perhaps the pea crop throughout the country generally, are still more below an average. Neither in its return of food for man nor in its promise of food for beast, does the harvest of 1870 compare favourably with its predecessors. Mr. Lawes, of Rothamsted, who has for twenty-seven years subjected the wheat crop to specific treatment of many different kinds, reports upon the other hand his produce to be this year above the average. There has been, he says, a splendid seed-forming and seed-maturing season, acting however in many cases upon an insufficient amount of plants, and it is probable therefore that some of the heaviest and some of the lightest crops ever known in England have been grown this year.

Among the leading agricultural events of the past quarter are the great annual meetings of the Royal Agricultural Societies of the three kingdoms. The English Agricultural Society at Oxford and the Highland Society at Dumfries have had capital meetings. The Irish Agricultural Society was less successful. One of the most interesting circumstances of the Oxford meeting was the award of a valuable prize to the best-managed farm of the district. It has been somewhat of a surprise and perhaps a disappointment to the agricultural optimists of the day, that the very competent jury appointed by the Society to examine the competing farms should have placed highest upon the list one which owes but little to the improved stock and implements whose use and introduction the Society has fostered. It is a somewhat old-fashioned style of management which has been thus decorated. The four-course rotation of wheat, turnips, barley, and clover in succession is the cropping of the farm; the live stock is inferior, and comparatively few modern implements are in use. The visitor who in the morning

left the showyard of the Society full of the best specimens of the finest breeds of all kinds of farm stock and every new agricultural machine, saw nothing of either on the "best-managed farm" which he walked over in the afternoon. He saw, however, magnificent crops of grain, and roots, and grass, obtained without their aid, and he might conclude that what was wanted for the improvement of English agriculture was not a Society stimulating the production of the best machines and live stock, but an agency for making farmers more energetic and laborious in the use of the common means already everywhere at their command.

This agency it is plain exists in an improved relationship between the landlord and the tenant. The nature of the best farm agreement has been the subject latterly of frequent discussion in the agricultural journals. The lease for a term of years, with freedom to cultivate the land as the tenant chooses up till within a few years of the close of the term, is certainly the system which gives freest scope to the intelligence and energy of the tenant, and most likely therefore to result in industrious and successful cultivation.

An interesting paper "On Wheat Flies" appears in the 'Agricultural Gazette,' from which we learn that *Cecidomyia tritici*, to which Professor Henslow drew attention thirty years ago as the most destructive wheat midge of his time, is no longer prevalent; and that the complaints now common of injury from the wheat midge are due to *Lasiopteryx obfuscata*. The former is a yellow fly, the latter black. The insect is not easily bred, neither Mr. Kirby, Mr. Curtis, nor Professor Henslow having succeeded. The successes of Miss Eleanor Ormerod, of Sedbury Park, Chepstow, which are recorded in the 'Agricultural Gazette,' seem to have been wholesale, notwithstanding her failures in detail. She placed on earth in different flower-pots, grubs and pupæ, with the ears and stalks to which they respectively adhered, as well from wheat as barley, protecting each with a covering of gauze or muslin. These were kept in the most natural conditions, and carefully watched and tended all through the winter and spring, without producing anything; but a small heap of wheat rubbish, which had been ascertained to be well supplied with grubs and pupæ, was left in an out-of-the-way corner by itself, and early in June was found to be swarming with a cloud of these small Cecidomyia-looking midges, *viz. Lasiopteryx*. "Numbers of these," says the writer whom we are quoting, "were also obtained, and sent to us from the wheat fields at different dates, but not a single specimen of the *Cecidomyia tritici* reached us. Now, is this abundance of *Lasiopteryx* and scarcity of *Cecidomyia* confined to the neighbourhood of Chepstow, or is it general over the whole country? If so, another question, which however, we can scarcely hope to fathom, is—when *Cecidomyia* ceased to be prevalent, and *Lasiopteryx* took its place. It may

even be a question whether *Cecidomyia* ever was generally prevalent—it may have been so only in Kirby's time and the London district."

The Rivers Pollution Commissioners have issued a report upon the so-called "A B C" process for defecating sewage. They pronounce it a failure. The sewage treated on this plan is not defecated, and the manure produced is extremely poor. The only advantage derived from its adoption is a somewhat quickened subsidence of the suspended matters which town sewage carries with it, but as every 10 cwt. of these are rattled through the sewers of a town, borne along in the case of a town with ordinary water supply in a thousand tons of water, it is not likely that these suspended matters can retain much that is soluble or valuable on their exit from the sewer system of a town. And in point of fact the solid matters of town sewage are of very little agricultural value indeed. It is the liquid portion that contains the elements of the food of plants; and it is this, therefore, in which these substances are present in too dilute a form to be precipitated that must be carried to the land, if either a nuisance is to be abated or a valuable property to be turned to good account. The Commissioners pronounce sewage irrigation to be the only method known to them by which both these results can be attained.

There has been an unusual prevalence of cattle disease during the past quarter. During the severely restrictive system under which alone cattle traffic was permitted during the prevalence of the cattle plague, the more common diseases, the foot-and-mouth affection and pleuro-pneumonia, almost disappeared. They have resumed their frequency and virulence with the relaxation of the rules affecting cattle-markets.

2. ARCHÆOLOGY (Pre-Historic).

*Primeval Monuments of Peru.**—Mr. E. G. Squier, the well-known American archæologist, has lately explored the early megalithic monuments of Peru. The great plateau of the Andes, elevated 13,000 feet above the sea, and fenced in with high mountains and frigid deserts, possesses nevertheless a number of stone structures belonging to what is regarded through the world as the earliest monumental period, coincident in style and character with the so-called cromlechs, dolmens, and "Sun" or "Druidical" circles of Scandinavia, the British Isles, France, and Northern and Central Asia.

Considerable importance attaches to these remains, as indicating

* By E. G. Squier, M.A., F.S.A., &c. From 'The American Naturalist,' vol. iv., 1870, p. 1.

the existence at one time in Peru of a population identical in the degree and stage of their constructive development with the people who raised corresponding lithic and megalithic structures in other parts of the world, and who, if not the progenitors of the semi-civilized nations found in Peru at the time of the conquest, certainly preceded them in the occupation of the country. Mr. Squier suggests that, "if it should be found that there has been a gradual development of any of the rude remains into elaborate and imposing monuments, corresponding with them in their purpose or design, or a gradual change from the rough burial-chamber of uncut stones into the symmetrical sepulchral tower, built of hewn blocks accurately fitted together, and in general workmanship coinciding with the other and most advanced and admirable structures of the country, then we may reasonably infer that the latter were constructed by the same people that built the first, and that, monumentally at least, the civilization of Peru was indigenous and gradually developed, and not introduced."

The first and simplest form of burial monument, and which the author assumes to be the oldest, consists of flat unhewn stones of various lengths set firmly in the ground, projecting above it from 1 to 2 feet, so as to form a circle, more or less regular, about 3 feet in diameter. In this circle, the body was buried in a crouching posture, with a vase of pottery or some other utensil or instrument at its feet. Sometimes a few flat stones were laid across the upright ones, so as to form a kind of roof. These rude tombs were sometimes placed side by side in long rows, and stones afterwards heaped over them. A more advanced form of tomb consists of large slabs of stone projecting 4 to 6 feet above ground, and set in a circle from 6 to 16 feet in diameter. The top is roofed by blocks of stone which lap over each other inwardly until they touch, forming a rude arch or vault. At Quellenata, N.E. of Lake Titicaca in Bolivia, and at many other places in the ancient Callao, these same tombs occur, but they are enclosed in a circular wall, varying from 10 to 30 feet in height, the stones broken so as to conform to the outer curve of the tower, and the whole cemented together with clay. These round *chulpas* are of varying excellence in workmanship and design, and lead up to the square *chulpas* of Escoma, the sides of which are vertical with a projecting cornice near the summit, and divided internally into two stories or chambers. At Sillustani the largest and best-built *chulpas* occur, constructed of great blocks of trachyte and other hard stones fitted together with unsurpassable accuracy, the structure nevertheless preserving some of the characteristic features of the first and rudest form of *chulpa*. The stones forming the dome are not only cut on accurate radii, but the curve of the dome is preserved in each, tending to give compactness and strength to the whole structure.

Mr. Squier also mentions that many stone structures exist in Peru, corresponding with the so-called Cyclopean monuments of Italy. He describes many sun-circles, some composed of simple upright stones, others having in addition a regular causeway of slabs, forming a platform of stone more or less hewn and fitted together.

In the ancient town of Chicuito, a singularly fine and massive rectangular monument exists, measuring 65 feet on each side. The author considers this to be the most advanced megalithic structure in Peru, and proposes in a future work to illustrate it more fully. When the whole of Mr. Squier's drawings are published, he believes all students of these archaic monuments will agree with him, that there exist in Peru and Bolivia, high up among the snowy Andes, the oldest forms of monuments, sepulchral and otherwise, known to mankind, exact counterparts in character of those of the "old world," having a common design, and all of them the work of the same peoples found in occupation of the country at the time of the conquest, their later monuments being developed forms of those by their ancestors, and the earliest the productions of primitive man in all parts of the world, and not derivative.

Mr. Squier has thus furnished another admirable illustration of the well-established law that "man under analogous circumstances will act in a similar manner irrespective of time or space."

Stone Implements from Burmah.—Mr. W. Theobald, jun., of the Indian Geological Survey, has communicated some notes on the stone implements of Burmah, to the Asiatic Society of Bengal. The implements are curious as differing in form and type, not only from anything found in India, but from anything hitherto described from any part of Europe, though any implement yet found in India has its precise analogue in Europe. These implements are not only singular in form, but also in the material out of which they are manufactured; being fashioned either of basalt or some schistose rock, quite unlike anything met with in the district where the implements occur: a fact which seems to indicate that they were brought down from Upper Burmah, where such implements are common, by the original settlers of the country. The same superstition which connects these implements with the "thunderbolt" prevails in Burmah, where they are called "mogio," or thunderbolts. Curious traditions prevail as to the virtues possessed by these heaven-born stones: such, for instance, as preserving from lightning, fire, shipwreck; conferring invulnerability upon the wearer; great medicinal virtues, a chip administered internally curing inflammation of the liver; it is also a specific for ophthalmia, &c. The types of these Burmese instruments described by Mr. Theobald are:—1. A rough, stout, wedge-shaped instrument, closely resembling the better finished specimens of flint-hatchets, of the type which occurs in the Danish kjökkenmöddings.

This form is very rare. 2. A hatchet with flat sides converging towards the base which is square, and with a segmental edge, much like the common German form. This type is common. 3. A long adze with square, slightly converging sides, and a bevelled segmental edge, in character much resembling some of the implements discovered in Java, Borneo, and Sumatra, and also a New Zealand form. 4. Implements of the same character, so far as the edge and sides are concerned, but having the butt end reduced in width so as to produce a square shoulder on each side of the blade. In some this reduction in width extends more than half the length of the blade, so as to produce a T-shaped form. These shorter specimens are the most common. This form appears to be peculiar to Burmah.

Mr. John Evans, F.R.S., F.S.A., offers some valuable critical notes upon Mr. Theobald's discovery, in 'Nature.'* He says:—

"In some cases the lashings used to fasten them to their hafts have left traces on the stone. The implements are usually picked up on the surface of the hills, and in the fields, or clearings made for cultivation, and not in the plains.

"Mr. Theobald seems inclined to doubt whether, without the use of iron also, those who made these implements could have effected clearances in the gigantic forests of Pegu; but it may be urged against this view that by calling in the aid of fire the efficiency of such tools is almost as great as if they had been formed of metal, and it is difficult to conceive a people in possession either of bronze or iron bestowing the necessary time and trouble on the fashioning of stone tools when those of metal were at their command, which, whether fire were employed in the clearance or no, were for general purposes so much more effective. If the makers of those stone tools had been in possession of other means for clearing the hill-sides, then Mr. Theobald would be inclined to regard the stone relics as agricultural implements used in hand agriculture, at the end of sticks, as a kind of spade, to form the shallow holes for the cultivation of 'hill rice.' If not explained in this manner, he argues, we must regard them as weapons of the chase and war, though this use is, he thinks, negatived by their thoroughly inefficient character for such purposes.

"To this may be objected, first, that the material of which they are usually formed is basalt, a stone constantly used as a material for cutting-tools; secondly, that the presence of the square shoulders, so like those on the horn sockets for hatchets of the Swiss Lake-dwellers, seems to testify to the tools having been used as adzes or axes, or possibly chisels; and thirdly, that if they had been required merely for hoeing or digging, the trouble of grinding and polishing might and would have been saved."

* Vol. ii., No. 32, p. 104.

*The Cheesewring threatened with Destruction.** —This very remarkable pile of rocks, six or seven miles north of Liskeard in Cornwall, is threatened with imminent destruction by quarrying operations at its foot. Will no one prevent its demolition? A committee was formed some time since for the express purpose of arresting by all possible means the Vandals who are everywhere plotting the overthrow of our ancient megalithic monuments. Surely the preservation of this fine dolmen is worth an effort.

The Meenas of Central India.—Lieut.-Colonel Showers has communicated to the Asiatic Society of Bengal an account of the Meenas, a wild tribe of Central India occupying the hilly and jungly country of Jehazpoor, where they appear to have maintained their independence and carried on a marauding life for centuries. They are described as a fine race of men, endowed with great personal courage, and addicted to the use of arms. They marry freely with other tribes, but never allow their daughters to marry out of their own tribe. Polygamy is allowed, each man having three or four wives. The aggregate male adults in the tribe is about 24,000.

Roman London.—Numerous remains of oxen and horned sheep were found some few years since on the site of old London Wall, near Moorgate Street. They had been all killed with the blow of a blunt instrument on the forehead, probably a stone celt. From associated relics there can be little doubt that this was one of the slaughtering places of the ancient inhabitants of London in Roman times. The Wall-brook evidently ran here, as the foundations of the old wall was built on piles. Another and recent excavation repeats the same story, and shows an old river-bed of silt, with numerous bones of animals.

Ethnological Society.

At the Ethnological Society papers have been read during the past quarter by Mr. C. Spence Bate, F.R.S., "On the Pre-historic Monuments of Dartmoor." Mr. Bate gives a melancholy account of the wanton destruction of the cromlechs in this district, and suggests obtaining legal protection for them before they are all demolished.

Dr. Caulfield records the discovery of copper celts near Buttevant, Co. Cork, and describes a supposed Ogham inscription from Rusglass, Co. Cork.

Lieutenant S. P. Oliver reports the recent destruction of another cromlech in Jersey.

Professor Huxley gave an interesting account of "the chief modifications of mankind, and their geographical distribution."

* 'Nature,' vol. ii., p. 101.

The characters of greatest value are—colour, character of hair, and form of the skull. The author described five distinct types. 1. The Australioid. 2. The Negroid. 3. The Xanthochroic, with fair skin and blue eyes. 4. The Melanchroic, a type with dark complexion, occupying an area between the Xanthochroic and Australioid peoples; and 5. The Mongoloid. The paper was illustrated by a large coloured map showing the distribution of these five groups and their subdivisions.

Professor Busk described the opening of the Park Cwm Tumulus in the peninsula of Gower, South Wales.

The Rev. Canon Greenwell read a paper "On his Exploration of Grimes's Grave, Norfolk" (see last Chronicle, p. 383).

Mr. Boyd-Dawkins gave an account of some remains of Platycnemic or Flat-shinned people in Denbighshire. The remains were found in two bone-caverns, a refuse-heap, and in a tumulus. Similarly-formed bones have been obtained from Cro-Magnon Cave in France, and the caves of Gibraltar.

Colonel Lane Fox described the Dorchester dykes and Sinodun Hill, and showed the works were British, and not Roman.

Mr. David Forbes, F.R.S., described the Aymara Indians of Bolivia and Peru. In stature they are small, massive, and thickset, with large heads and short limbs. The trunk is disproportionately large, and the capacity of the thorax enormous, being adapted to meet the requirements of respiration at an altitude of 8000 to 16,000 feet above the sea-level, where the atmosphere is proportionately rarified. Many interesting customs, &c., relative to this people were recorded by the author.

Anthropological Society.

Dr. Hudson read a paper "On the Irish Celt;" Mr. G. H. Kinahan "On the Race Elements of the Irish People;" and Dr. Beddoe "On the Kelts in Ireland." Dr. Beddoe describes the Irish as a dark-haired but light-eyed race, and he argues that wherever there is light hair it may be accounted for by the Danish or English intercrossing. The dark hair of the Irish may be, partly at least, attributed to the Gaelic Kelts.

3. ASTRONOMY.

(Including Proceedings of the Astronomical Society.)

As we write, the prospects of the eclipse expeditions hardly appear so favourable as could be wished. It seems doubtful whether Government will be willing to aid the expeditions by supplying the

means of transport,—the reason suggested for the expected refusal being the war which is at present devastating France. We can scarcely believe, however, that the Government will abide by this resolution. Remembering that some of the most important of those researches which adorn the annals of English science have been prosecuted under Government protection, and with Government aid, while England has been in the throes of deadly warfare—nay, when the very existence of England has been at stake—we refuse to believe that the mere risk of war should cause our Government to refuse a single ship in aid of scientific observations of extreme interest and importance.

Unfortunately, the mere report of such a probability has sufficed to check the process of preparation; and despite our confidence that England is not destined to suffer shame in this matter, we are compelled to recognize the possibility that the only systematic observations of this important eclipse will be made by French astronomers in Algeria.

Further on will be found an account of the extent to which the eclipse will be partially visible in this country.

Dr. Zöllner, known as one of the most successful students of solar physics, has been inquiring into the evidence which the form and dimensions of prominences afford respecting the temperature and physical condition of the sun. He points out that prominences may be divided into two classes, the cloud-formed and the eruptive prominences. Those belonging to the latter class are so obviously due to real eruptive action that we may fairly refer them to the same general cause as terrestrial eruptions, that is, to a difference between the pressure in the region whence the erupted matter flows and the pressure in the space into which that matter passes. But this view requires us to believe that there is a barrier-layer (*Trennungschicht*) by which one region is separated from the other—a stratum limiting the compressed hydrogen below the chromosphere from the free atmosphere of hydrogen which constitutes a proportion of that envelope.

Starting with this hypothesis, Dr. Zöllner proceeds to apply the mechanical theory of heat to determine the temperature of different portions of the sun's globe. We see that the prominences are projected to a certain height, and we have therefore a means of determining the force exerted in the propulsion of the compressed hydrogen. The equations for this purpose are those resulting from the law of Mariotte and Gay-Lussac, and those which are deduced from the theory of heat. Certain assumptions have to be made, the probability of whose truth depends on the interpretation of telescopic and spectroscopic observations of the sun.

Some of the results are of great interest, especially as, even though the fundamental suppositions should be importantly in error,

the conclusions would still be but slightly affected. Zöllner finds the minimum temperature of the base of the solar atmosphere to be about 27,700° Centigrade, and the corresponding temperature in the region whence the prominences are projected to be about 68,400° Cent. He calculates the pressure in this last-named region at 4,070,000 atmospheres, while the pressure outside the stratum enclosing this region he calculates at 184,000 atmospheres. He then shows that whereas these results have been obtained on the supposition that the pressure at the base of the chromosphere is but that corresponding to about 7 inches (180 mm.) of the mercurial barometer, the actual pressure of the nitrogen and oxygen atmospheres at this level must be almost infinitely minute. But he remarks that this alone does not suffice to explain the absence of the lines of these elements from the spectrum of the sun, since the lines of volatilized metals are seen. He attributes the visibility of the latter lines to the fact that the vapours of the metallic and alkaline elements have a much greater emissive power, and consequently a much greater absorptive power than those of the permanent gases.

To proceed further with the discussion of his researches would bring us upon ground altogether removed from astronomy. We may remark, however, that there is one point which seems to us to have been too little considered in these and similar researches. It is assumed that spectroscopic researches enable us to determine the actual pressure at the base of the chromosphere. As a matter of fact, we have no means of knowing whether the estimated pressure belongs to the base of the chromosphere or to a height of ten, a hundred, or even a thousand miles above the solar photosphere. It must be remembered that 1000 miles at the sun's distance subtends little more than two seconds of arc, the minuteness of which distance will be appreciated by those who have examined double stars two or three seconds apart, even with very powerful telescopes. Assuming that with the magnifying power employed (magnifying power being an essential element in such applications of the spectroscope as we are here considering) an arc of two seconds could be recognized, yet the tenth part of such an arc would be wholly inappreciable. Now the increase of pressure within a distance of 100 miles from the base of the chromosphere is probably more considerable than that occurring throughout all the thousands of miles of chromospheric height above that level.

The most important astronomical event of the next quarter is undoubtedly the great eclipse of December 22nd next. In England it will be considerable though not total. The following are the data for the principal places in the British Isles:—

At Greenwich the eclipse will begin at 11 h. 8 m. A.M., reach its greatest phase at 12 h. 25 m. (when 0·814 of the sun's disc will be concealed by the moon), and end at 1 h. 42 m. P.M.

At Cambridge the eclipse will begin at 11 h. 9 m. A.M. (mean time at Cambridge), reach its greatest phase at 12 h. 26 m. (when 0·808 of the sun's disc will be concealed), and end at 1 h. 42 m. P.M.

At Oxford the eclipse will begin at 11 h. 1 m. A.M. (mean time at Oxford), reach its greatest phase at 12 h. 18 m. (when 0·813 of the sun's disc will be concealed), and end at 1 h. 35 m. P.M.

At Liverpool the eclipse will begin at 10 h. 52 m. A.M. (mean time at Liverpool), reach its greatest phase at 12 h. 8 m. (when 0·804 of the sun's disc will be eclipsed), and end at 1 h. 24 m. P.M.

At Edinburgh the eclipse will begin at 10 h. 53 m. A.M. (mean time at Edinburgh), reach its greatest phase at 12 h. 7 m. (when 0·788 of the sun's disc will be concealed by the moon), and end at 1 h. 21 m. P.M.

Lastly, at Dublin the eclipse will begin at 10 h. 34 m. A.M. (Dublin mean time), reach its greatest phase at 11 h. 50 m. A.M. (when 0·812 of the sun's disc will be eclipsed), and end at 1 h. 6 m. P.M.

We may remind our readers that on the 12th, 13th, and 14th of November, shooting stars may be looked for. A year or two back it was possible to indicate somewhat more definitely the time when the display was to be expected; but it needs only a careful study of the phenomena presented by the successive showers, since the great one of 1866, to prove that the meteor-system has been widening out, growing in the meantime less and less rich: so that while we may be tolerably certain of seeing many November meteors, there is small chance of a display resembling that of the year 1866.

The planet Jupiter will be well situated for observation during the next quarter, coming to opposition on December 13th. Saturn on the contrary is passing away from our nocturnal skies, and will be in conjunction with the sun on December 22nd. Mars is returning, but only at the end of the year will he be near enough to be worth studying telescopically. He comes into opposition on March 19th, 1871.

Proceedings of the Astronomical Society.

Lieut. Brown supplies an important paper on December weather in the neighbourhood of Gibraltar. It appears from the meteorological observations he records that there is every reason to anticipate favourable weather during the eclipse of December 22nd next. From the 15th to the 31st December there were in 1860, 6 very good days; in 1861, 3; in 1862, 10; in 1863, 13; in 1864, 5; in 1865, 12; in 1866, 6; in 1867, 8; in 1868, 11; and in 1869, 7; —the bad days in those years numbered, respectively, 5, 9, 1, 1, 2, ½, 2, 3, 1, 1. So that in all there were 81 good days and but 25½ bad ones, the remaining 64½ being indifferent.

Commander Ashe endeavours to show that the Council of the Astronomical Society were not justified in expressing the opinion that "in photographs 3 and 4" (of his set of 4, illustrating the American eclipse) "there is evidence of the disturbance of the telescope during the exposure of the sensitive plate. But there seems every reason to accept the opinion of the very able committee appointed by the Council to consider the matter, and the members of this committee "unanimously report that in their opinion there was a decided movement of the instrument at the time the photograph was taken; a conclusion arrived at from an examination of the chromosphere close to the moon's limb, as well as from an examination of the prominences."

In a description of the occultation of Saturn by the moon on April 19, 1870, Captain Noble dwells on the exceeding sharpness of Saturn's definition; the most delicate details being perceptible, even in contact with the moon's limb. The crape ring C was seen most perfectly where the dark limb of the moon crossed it. "I never was more impressed," remarks this skilful observer, "with the absolute absence of a lunar atmosphere of any appreciable density than I was on this occasion."

Mr. Penrose, from observation of the star Algol, concludes that the period of 2·86727 days assigned to this remarkable variable in Herschel's 'Outlines of Astronomy' requires to be slightly corrected. The minima occurred nearly three hours earlier than the epochs calculated with the above period from a minimum which occurred on January 3, 1844. The shortening of the period of this variable is certainly a remarkable and interesting circumstance. Observers should watch from time to time the occurrence of the well-marked minimum, in order to see whether the reduction of the period is steadily progressing, or to detect signs of its being eventually transmitted into the reverse process, as in the case of planetary perturbations.

Mr. Proctor, in a paper "On the Resolvability of Star-groups regarded as a Test of Distance," points out that there is good reason for doubting whether we can form any opinion whatever respecting the distance of a cluster of stars from the telescopic power necessary to completely resolve it. He shows that a star-group may be so constituted that let its distance be ever so great it cannot appear nebulous, or again that conceiving its distance to be increased so that it passed eventually beyond the range of our most powerful telescopes, it would pass from irresolvability to resolvability and again to irresolvability through the mere effect of a continually increasing distance. The question of the resolvability of a star-group depends not on distance alone, but on the relation between the magnitudes of the component stars and the distances separating them. If the magnitudes are such that the stars would vanish in-

dividually through increase of distance, before their distances from each other became evanescent, the group (or the special order of stars considered—as the case may be) could not possibly present a nebulous appearance, at any stage of its recession, with whatever telescopic power it was studied. On the other hand, if the distances between the stars became evanescent before the stars vanished individually, the group or order of stars must necessarily become nebulous when it reached a certain distance. In the case of a group consisting of several orders of stars, one order might thus become nebulous at a certain distance, but with yet greater increase of distance this nebulosity would vanish, and the question whether any new nebulosity would replace it would depend wholly on the question whether the next higher orders of stars belonged to one or other of the classes considered above. Considerations thus applied to a group of stars passing away from the eye, may obviously be extended to star-groups at various distances; and since we could not judge of the distance of the moving group from its resolvability or irresolvability, so neither can we place any reliance on those estimates of the distances of nebulæ which have been founded on their resolution.

Mr. Williams describes some early telescopes made by Giuseppe Campani which he purchased at the sale of the late Dr. Lee's instruments. Readers of the 'Celestial Cycle' and its 'Prolegomena' will not need to be reminded that these instruments were tested by the late Admiral Smyth.

Mr. Powell communicates a paper "On the Double Star α Centauri." The companion has recently reached its lesser maximum of distance, and has commenced its return towards the primary. Thus an exactitude of determination has become possible, which (as Captain Jacob used to remark) was impossible while it remained unknown how far the companion would pursue its northerly excursion. The following are the elements which Mr. Powell now assigns to the orbit:—

Longitude of periaster ..	38°·40	Semi-axis	20″·13
Eccentricity	·63944	Period	76·25
Rising node	21°·18	Periastral passage	1874·2
Inclination	81°·13		

These results differ somewhat importantly from those obtained by Sir John Herschel, Hind, and formerly by Mr. Powell himself.

Mr. Seabroke endeavours to show that Mr. Lockyer's theory that the corona is a phenomenon of the earth's atmosphere "is quite possible." For this purpose he considers how far such spectroscopic results as Major Tennant obtained during the Indian eclipse, might be accounted for on that theory. It is unfortunate that in place of dealing with the actual circumstances of that eclipse, Mr. Seacombe determines "what spectrum we ought to obtain from a corona at

a point on the earth where the limbs of the sun and moon are in a line; that is, where the eclipse is total exactly." In any given total eclipse the coincidence of the limbs of the sun and moon is necessarily a momentary phenomenon; and the state of things at the moment is altogether exceptional. What has to be explained before Mr. Lockyer's strange theory can be admitted, is the observed state of things when lines from the sun's limb to the moon's disc fell eighty miles or so from the observer's station. Mr. Lockyer himself has begun to recognize the necessity of explaining away this difficulty, and he now supplements his theory by introducing "a possible action at the moon's limb," though what the nature of that action may be he forbears to indicate.

Mr. Browning gives an account, accompanied with illustrations, of his ingeniously devised automatic spectroscope referred to in our last. When this paper was read before the Royal Astronomical Society, Professor Pritchard stated that he had given several hours to the examination of the optical relations of the new instrument, but could not definitely assert that minimum deviation is secured for rays of all orders of refrangibility. Although the instrument is probably as perfect practically as it can be made by whatever further refinements may be adopted, it requires but little consideration to show that it does not in its present form theoretically secure true minimum deviation for all rays. The fixity of the first prism (the collimator being also fixed) suffices to prevent this. We believe that Mr. Browning is now at work on a modification of his instrument which has been suggested to him, in which this objection is obviated.

Fr. Perry, of the Stoneyhurst Observatory, gives an account of an observation made on Winneeke's new comet (discovered on May 30, at Carlsruhe). He had searched in vain for D'Arrest's comet. Mr. Hind sends the elements (calculated by Winneeke himself) of the former comet, which is described as a round pretty bright nebula, about 2½ minutes in diameter.

Lieut. Hill, on May 22, saw three large spots on the sun, with the naked eye. On the following day a fourth spot was visible. We believe that this is the first instance on record in which so many spots have been seen without telescopic aid.

In a paper on the stereographic projection, Professor Cayley points out that the very same circles which in the direct stereographic projection of a hemisphere (*viz.* that wherein the projection is on the plane of a meridian) represent the meridians and parallels respectively—represent also in the oblique projection of the hemisphere meridians and parallels respectively.

Mr. Lynn discusses the proper motion of the star "Groombridge, 1830." He finds as the final result of his examination of the

Greenwich records of this star, the following mean annual proper motions in four several intervals:—

Years.		Proper Motion in R. A.		Proper Motion N. P. D.
1845–1850	.. ..	$+0^{s}\cdot358$	.. ..	$+5''\cdot82$
1850–1860	.. ..	0·343	.. ..	5·73
1860–1864	.. ..	0·336	.. ..	5·93
1864–1869	.. ..	+0·338	.. ..	+5·71

We may fairly assume that the mean of these values (properly weighted) represents the true value of the star's motion—which it will be seen is exceptionally large.

4. BOTANY.

Evaporation of Water from Plants.—Some researches have recently been undertaken by Von Pettenkofer on the amount of evaporation which takes place from the foliage of plants. The experiments were made in the case of an oak tree, and extended over the whole period of its summer growth. He found the amount of evaporation to increase gradually from May to July, and then decrease till October. The number of leaves on the tree were estimated at 751,592, and the total amount of evaporation in the year at 539·16 cubic centimètres of water for the whole area of the leaves. The average amount of rainfall for the same period is only 65 cubic centimètres; the amount of evaporation is thus $8\frac{1}{2}$ times more than that of the rainfall. The excess must be drawn up by the roots from a great depth; and thus trees prevent the gradual drying of a climate, by restoring to the air the moisture which would otherwise be carried off by drainage.

Germination of Palms.—Mr. J. W. Jackson, Curator of the Museum at Kew, has published a useful paper "On the Germination of Palms." This is incorrectly described in all the botanical text-books commonly in use. The peculiarity consists in the end of the cotyledon remaining in the seed, whilst its stalk is pushed out, carrying with it the radicle, which germinates in the usual manner at a little distance from the seed. In the double cocoa-nut, *Lodoicea*, the protruded end of the cotyledon is as much as 12 or 18 inches long. The sheath or socket at the base of the stem of this palm is shown not to be peculiar to it, as has been supposed, though more developed than in other species, and to be formed by the vascular bundles of the rudimentary and early leaves.

Existence of a Formative Layer in the Leaves of Plants.—M. Cave has recently pointed out that a formative layer exists in the leaves of plants, similar to the well-known cambium layer, which, in exogenous plants, intervenes between the bark and the

wood, and from which the new wood is formed. He finds it not only in the leaves, but in all foliar or "appendicular" organs, normal or modified, as for instance the flowers, but occupying a different position to the cambium layer, namely, between the tissue of the organ itself and the epidermis. The knowledge of this fact M. Cave applies to determine a morphological question which is often a matter of controversy, whether a particular organ belongs to the axis, to the foliage, or to both sets of organs combined; and he shows that if the formative layer is exterior to the fibro-vascular system, the organ belongs to the leaves; if interior to it, to the stem. The application of this test proves that the receptacle-like perigynous calyx of many plants is a dependency of the axis; while the pericarp of superior fruits is always formed of metamorphosed leaves and nothing else; this is also the case with the axile and parietal placentæ; but the free central placenta, as in the case of *Primulaceæ*, is a prolongation of the axis. Fruits proceeding from an inferior ovary are composed of two parts, varying in their mutual proportion in different plants, a receptacle-like calyx and carpellary leaves. It is noteworthy that M. Cave found this formative layer to occupy the same position in the leaves and fruits of endogens as in those of exogens.

Changes in the Colour of Flowers produced by Ammonia.—M. Vogel has recently published the results of some experiments on the changes produced by ammonia in some vegetable colours, especially those of flowers, which he thinks may be of practical importance in the manufacture of vegetable colouring matters of a character similar to the aniline dyes. The colouring matter he states to be of two kinds, united with a different degree of persistence to the tissue of the flower itself, and requiring a shorter or longer time to produce any alteration. The change produced in the colour of some flowers, as the rose and phlox, by the fumes of tobacco, is entirely due to its ammoniacal element. M. Vogel found that some colours are altogether unchanged by lengthened exposure to ammonia; as, for instance, yellows, all reds (except in the case of the *Zinnia*, which is converted into a brown-red), and dark violets. Blue is sometimes unaltered, sometimes changed into a dirty green and then bleached. In some cases, not only the colour but the tissue of the flower is destroyed. The changes are generally the same as those that take place during the withering of the flower.

Electricity in Plant Life.—A writer in the 'Gardener's Chronicle' points out the important part played by electricity in the phenomena of vegetable life. He states that every hair and sharp point in the vegetable kingdom is necessarily a conductor of electricity, which must always be present wherever water rises in the form of vapour. Hence all the young and growing parts of

plants are clothed with delicate hairs; and the same is generally the case with those fruits or other parts which have a very fine and delicate scent or flavour, these qualities being, the writer believes, greatly developed by the agency of electricity.

Poisoning by Œnanthe crocata.—Mr. Worthington G. Smith records an instance of poisoning by the water dropwort, *Œnanthe crocata*, a common Umbelliferous plant in the South of England. A carter, whilst at work, ate some of the roots, supposing them to be wild parsnips; in about an hour he became unconscious and convulsed, and death occurred in another half-hour, before medical assistance could be obtained. The man had fed his horse with roots of the same plant, and the animal also expired about two hours after eating them. The plant belongs to that group of narcotico-acrid poisons comprising the *Solanaceæ* (Belladonna, Hyoscyamus, &c.), and characterized by producing convulsions with delirium. The juice of the plant was in this instance of a yellow colour; it has been stated that a variety of the plant with colourless juice is a less virulent poison. The taste of the root is said to be intermediate between that of celery and turnip.

Mistletoe on the Oak.—Dr. Bull records, in the 'Transactions of the Woolhope Naturalists' Field Club,' a very interesting case of this extremely rare occurrence. The tree grows in the hedge-row of a field called the Harps, at Haven Aymestry, in the ancient forest of Deerfold, in Herefordshire. It was discovered in the spring of 1869, but the mistletoe must have been growing on the oak for some years. The oak is of the variety *sessiliflora*, and may be some fifty or sixty years old. The mistletoe is a female plant, and grows high up on the main stem. It forms a large spreading bunch, with a diameter of 3 feet 6 inches, and springs out from the oak in a single stem, nearly 4 inches in circumference. The mistletoe is also growing on a thorn close by, and has probably sprung from a seed dropped by a bird from above. The great rarity of the growth of mistletoe on the oak is proved by the fact that there are but eight examples which have been well authenticated as existing at the present time; the localities being Eastnor Park, Herefordshire; Tedstone Delamere, Herefordshire; Forest of Deerfold, Herefordshire; Frampton-on-Severn, Gloucestershire; Sudbury Park, Monmouthshire; Dunsfold, Surrey; Hackwood Park, Hants; and one near Plymouth.

The Cinchona in the West Indies.—In a recently-issued Colonial Blue-Book, Sir James P. Grant, the Governor of Jamaica, states that the cinchona plantation in that island may now be pronounced a complete success. Cinchona plants were first received in 1866. By the close of 1867 the number of young plants had so much increased, that it became necessary to provide land for their final establishment on a planter's scale. Six hundred acres of

virgin forest in the Blue Mountain were acquired early in the year, and were set apart for the purpose of a cinchona plantation, for which the place is in every way admirably suited. The elevation varies from 4000 to 6000 feet. It is well watered, has the best aspects, and possesses a soil reported to be admirably adapted to the requirements of the cinchona. Fifty acres were cleared, of which forty were filled with cinchonas in the course of the year; about 20,000 plants of five different species having been planted. By the latest accounts all of these were in full vigour, and the plantation must by this time be doubled in extent. The plants have stood one of the driest seasons that has ever been remembered on Blue Mountain, without suffering in the least. There is now no doubt that the cinchona can be successfully reared in Jamaica.

Origin of Prairie Vegetation.—Professor Winchell, of the University of Michigan, has recently promulgated a new theory respecting the origin of the vegetation of the American prairies, namely, that it dates back beyond the historical epoch to the Glacial period. He believes the origin of the prairies to be lacustrine; but, contrary to the generally-received opinion, he maintains that lacustrine sediments contain no living germs. Diluvial deposits, he states, on the contrary, are found everywhere replete with living germs, which, when hidden away from the influence of light and moisture, retain their vitality or power of germination for an indefinite length of time. These living germs of the diluvial deposits he believes to have been buried during the glacial period, in the course of which the surface was ploughed up by glaciers, and afterwards exposed to the commotion of the sea, which overspread the land, burying everything in promiscuous ruin; but yet by this very means storing away the seeds which, when brought to the surface after the lapse of a geological age, are possessed of vitality, and able to reclothe the barren earth with verdure and beauty. Thus, in proportion as the diluvial surface became exposed, the flora of the pre-glacial epoch was reproduced. In support of this theory, he brings forward the argument that the fossil plants which have been discovered in the tertiary deposits show a correspondence of genera, and in some cases even of species, with those existing at the present time.

The Herbarium of the British Museum.—The Curator of the British Museum Herbarium has just published his annual report of the national collection. A considerable number of families have been re-arranged, and collections incorporated in the general herbarium from Mexico, New Granada, Nicaragua, Ecuador, California, India, and other countries. The most important additions to the herbarium have been 2000 plants from Abyssinia, and upwards of 3000 from South Africa, as well as more than 1000 European plants, and a number of smaller collections. Various portions of

the British herbarium, and the collection of fruit and seeds, have been re-arranged, and the recent and fossil *Coniferæ* and *Cycadeæ* have been examined and arranged.

The Botanic Garden at Brussels.—The Belgian Government recently purchased the magnificent collection of dried plants of the late Von Martius as the nucleus of a national herbarium. It has more recently concluded the purchase of the Botanic Garden belonging to the Horticultural Society of Belgium; and has thus commenced the formation of a national establishment intended to rival those of Paris and London.

5. CHEMISTRY.

Of all the non-metallic elements, fluorine appears the most difficult to bring under the domain of organic chemistry; very few compounds of this element with carbon, hydrogen, and nitrogen being known. Dr. R. Schmitt and H. von Gehren have recently succeeded in preparing Fluorbenzoic acid and Fluorbenzol. Fluorbenzoic acid is prepared from diazo-amidobenzoic acid by treating that substance at a high temperature in a platinum basin with hydrofluoric acid. The fluorbenzoic acid thus obtained resembles, as far as its physical properties are concerned, benzoic acid; it is, however, far more volatile, fuses at 182° C., is difficultly soluble in cold, readily in hot water, and soluble also in ether and alcohol; its aqueous solution exhibits a strongly acid reaction to test-paper and decomposes inorganic carbonates very readily; the acid does not act upon glass, and is a very fixed substance, which may be even dissolved in concentrated sulphuric acid without decomposition. Fluorbenzol is a crystalline solid, boiling at about 183° C., fusing at 40°, insoluble in water, and specifically heavier than that liquid, readily soluble in ether and alcohol.

Whilst organic chemistry is aptly called the chemistry of carbon, Drs. Friedel and Ladenburg are engaged in researches which tend to place silicium parallel to the former element. They have succeeded in preparing what they call silico-propionic acid, a compound wherein a large percentage of the carbon of propionic acid is replaced by silicium. The physical aspect and many of the properties of this body are akin to silica; but it is a combustible substance, insoluble in water, but soluble in a hot and concentrated solution of caustic potassa. M. Dumas observed, in reference to this paper, that it is not impossible that there exist in nature organic compounds of silica, a remark which gave rise to some observations on Dr. Friedel's 'Memoir,' by P. Thenard. The author begins with stating that M. Dumas is quite right, and

relates further that he (M. Thenard) is at present engaged on researches of organic acids which contain even 24 per cent. of silica entirely disguised. When ulmic acid is treated by ammonia, azhumic acid is formed; this contains nitrogen so fixedly, that it is only eliminated at a temperature of about 1200°. This acid is possessed of the remarkable property of readily dissolving silica, and combining therewith in the same manner as the compound alluded to above by Dr. Friedel. The author also states that although his researches on this subject are not yet quite concluded, he is justified in stating that all arable and garden soil, and far more so farmyard manure, contain similar organic silicious compounds which play an important part in the feeding of the plants.

That indefatigable savan, the Abbé Moigno, has recorded that when picric acid is introduced into a vessel containing ozone, a violent detonation instantaneously takes place, a new proof of the danger attending experiments with nitrogenous compounds containing nitrogen, only loosely bound.

The utility of mixing peroxide of manganese, for which, however, may be substituted substances such as peroxide of iron, oxides of zinc and tin, burnt gypsum, and others, provided they are previously well dried (best by ignition) with chlorate of potassa, is based according to Dr. G. Krebs upon the fact that the substances alluded to, which are infusible by themselves, are the carriers and transferers of heat to the chlorate of potassa, each particle of which is surrounded with a source of heat, which aids its rapid decomposition. The peroxide of manganese is prevented from being itself decomposed, because the chlorate of potassa withdraws from it heat, for the purpose, first of its own fusion, whereby heat becomes latent; secondly, by its decomposition. The author states that when oxide of iron, or peroxide of manganese, is strongly heated in a crucible, and chlorate of potassa very gently fused at the same time by itself in a porcelain dish, the addition of the moderately hot oxides to the fused chlorate causes the evolution of oxygen to set in instantaneously, and with so great violence, that unless this experiment be performed in open vessels and with small quantities at a time, serious explosions may occur.

A compound of hydrogen and mercury, which the discoverer calls Hydrogenium-amalgam, has been prepared by O. Loew, by shaking together in a vessel, to be kept very cool, a mixture of mercury containing from 1 to 2 per cent. of metallic zinc, along with an equal bulk of a solution of chloride of platinum containing 10 per cent. of solid chloride. A slimy mass is obtained, devoid of metallic lustre and prone to decomposition, owing to the presence of zinc and some compounds of that metal; but on treating the mass with dilute hydrochloric acid, a body having the consistence

of butter is obtained, which according to the author is a true amalgam of mercury and hydrogenium. The author describes at length several reactions of this body, which in many of its properties is akin to hydrogenium-palladium. Professor C. A. Seeley, speaking of this amalgam and the allied ammonium amalgam, gives it as his firm opinion that they are only mechanical mixtures of mercury and gases. In illustration of this he describes an important experiment to prove that if ammonium amalgam be subjected to varying pressure, its volume changes, apparently, in accordance with Mariotte's law of gaseous volume. To illustrate this, a glass tube $\frac{1}{3}$ inch in diameter, 20 inches long, and fitted with a plunger, was employed. Mercury containing a little sodium was poured into the tube to $\frac{1}{3}$ inch in depth; and upon this was poured a strong solution of chloride of ammonium occupying about 2 inches in length of the tube. The ammonium amalgam was completely formed in a few minutes, and occupied several inches of the tube. On adjusting and depressing the plunger, the volume of the amalgam progressively diminished till it closely approached the original volume of the mercury. Also, it was notable that the amalgam progressively gained fluidity and the mirror surface till, at the greatest pressure, the original volume and appearance of the metal were resumed, whilst on reducing the pressure below that of the air, the amalgam still expanded until it rose above the surface of the liquid in the tube. If the great pressure be maintained, more ammonium amalgam will be formed, the mass expanding progressively, apparently in accordance with the fact that the absorption or adhesion of gases to liquids is favoured by pressure. By means of the simple apparatus used, a pressure of ten atmospheres or a good vacuum are easily and at once obtainable, and the experiments with it are very striking. The considerations regarding ammonium amalgam are evidently equally applicable to Loew's hydrogenium amalgam; both may be only metallic froths. The expansion of palladium observed by Graham, on its absorption of hydrogen, is probably analogous to the case in question. In both cases, the gases concerned are condensed, by reason of their attraction to the metal; and if the molecules of palladium were made free to move, as those of mercury, it is probable that Graham's hydrogenium alloy would become a palladic froth, more remarkable than the corresponding mercuric froth.

The presence of manganese as an essential constituent of milk and blood (human as well as animal) has been known for about twenty years past, but E. Pollacci gives some particulars about the method of detection of this metal in the two animal fluids referred to. The milk which contains this metal in the largest proportion is first evaporated to the consistency of a paste; this is carbonized by heat in a platinum crucible; the charcoal thus obtained is

pulverized and next completely incinerated; the ash is triturated in an agate mortar and lixiviated with water; the residue is treated with very pure nitric acid, and the solution thus obtained is evaporated to dryness and calcined in a test-tube; after cooling, a few drops of nitric acid are added, and the contents of the tube again boiled; next a few grains of puce-coloured oxide of lead are added and the liquid again boiled; a more or less deeply purplish-coloured liquid appears on leaving the tube at rest for a short time, which is due to the formation of permanganic acid. No quantitative researches have as yet been made by the author.

All chemists must have suffered inconvenience by finding that their test-solution of tartaric acid had become mouldy. Many remedies for this decomposition have been suggested, but none appear so simple as the one proposed by William H. Wood, of Middlesbro'-on-Tees. This chemist has made known that if a solution of tartaric acid in water, whether mouldy or not, be filtered and then boiled for a short time (say ten minutes), it will not afterwards become mouldy, whether corked or stoppered up in a bottle, or left exposed to the air. This statement will, if confirmed, be important as bearing on the so-called "spontaneous generation" controversy, and may throw some light on it.

The production of a crystalline alloy of zinc and calcium has been observed in the preparation of calcium by the process of M. Caron, in which an excess of zinc was employed. It contains about 95 per cent. of zinc and 5 per cent. calcium, corresponding to the formula $Zn_{12}Ca$. These crystals are small octahedrons with square bases. They are acted upon by water with the liberation of hydrogen.

Dr. W. Stein has devised an easily-executed process for the detection of madder colours upon cloth or by themselves. He boils the cloth with a concentrated solution of sulphate of alumina, whereby a liquid is obtained of reddish colour, exhibiting a golden-greenish fluorescence, due to the presence of purpurine; the behaviour of the colouring matters of madder towards sulphate of alumina is so characteristic that this salt may serve as an effective test for these substances; the alizarine may be readily rendered soluble by treating the dye material or dyed cloths with alcohol acidified with hydrochloric acid.

As a result of a lengthy series of experiments, M. E. Baudrimont concludes that tin-foil, in consequence of its impermeability for water, may serve with great effect to protect various substances from the effects of the atmospheric moisture, as well as act as a protective against the alterations fruit undergoes by evaporation of the fluids therein contained; tin-foil also protects against the oxidizing action of the oxygen of the atmosphere, and may hence serve

to keep fatty substances from becoming rancid, while it may usefully serve in laboratories to wrap up caustic lime, bisulphite of soda, and similar substances, which may thus be preserved for a great length of time without deterioration.

The cause of the precipitation of muddy matter from water by the aid of dilute saline solutions has been investigated by Dr. Ch. Schlasing. Water otherwise pure, but contaminated simply with clay (as may be the case with the water of rivers after heavy rain or fall of snow), becomes at once clarified by very minute quantities of some salts of lime: $\frac{1}{1000}$th part of chloride of calcium for 1 part of water effects this purpose in a moment; the nitrate, bicarbonate, and caustic lime act in the same manner. The precipitated substance may be readily separated from the water by filtration, whereas the filtration of the water containing the suspended matter is very difficult, because the pores of the filters become choked. The practical importance of this matter is very great, since it is, for instance, a well-known fact that the water of some rivers (the Durance being notorious in this respect) does not, in winter time, and after heavy rainfall or snow-storms, become quite clear, even if left at rest in large ponds for a considerable time. The same is the case with the water of the Rhine, which in its lower course is often turbid for weeks together, simply from the effects of very finely-divided clay being suspended even after the water has been at rest in tanks. The water of the river Durance supplies Marseilles with fresh water, the latter being brought to that city by a magnificent series of works, among which may be mentioned the celebrated Aqueduc de Roquefavour. Certain bitter vegetable substances have been applied both in Egypt and in India, for the purpose of rendering the waters of the Nile, Ganges, Indus, and other large rivers, potable, many centuries before the *rationale* of the action of these substances was understood.

6. ENGINEERING—CIVIL AND MECHANICAL.

The Mitrailleur.—Unfortunately the peaceful progress of Engineering Science has, within the last few weeks, been suddenly interrupted by the outbreak of hostilities on the Continent; and prominence has consequently, for the time, been obtained by that branch of engineering which devotes its energies to the production of warlike engines and materials. For some years past attention has been given to the improvement of our artillery, and the revival of breech-loading cannon, which for a while was received with much favour, is already beginning to find strong opponents from the fact that, as a rule, they possess less precision than the old muzzle-

loaders. Steel and chilled iron also appear likely again to give place to bronze as a material for field guns. The arm of the day is, however, the mitrailleur, or mitrailleuse as it is sometimes called, which has already performed such bloody work in the present war. The mitrailleur belongs to the same class of weapon as the revolver, having, however, this advantage, that its barrels may be fired almost simultaneously. One of the earliest of this class of weapon was the American Gatling gun, which was first seen in Europe at the Exhibition of 1867. This consists of six barrels mounted in two rings of iron, fixed on a central axis; at the rear of these are two half-cylinders of iron, bolted together, which serve to enclose and protect the mechanism; within these a cylinder revolves, with grooves into which cartridges fall as it is turned round, and by a self-acting mechanism they are pushed forward into the barrels, fired, and the empty cases subsequently extracted. A continuous and rapid fire can thus be maintained as long as there remains ammunition at hand to continue feeding the breech. The mitrailleur which has recently been subjected to comparative and experimental tests at Shoeburyness, is of Belgian origin; it was introduced into this country by Major George Fosbery, V.C., of the Bengal Staff Corps. It was invented in 1867 by M. Montigny, but has received several modifications and improvements since that date. This weapon consists of thirty-seven steel barrels, of an hexagonal form exteriorly, fitted and soldered together, and finally surrounded by a wrought-iron tube. To the tube or barrel thus constituted a breech attachment is screwed, and the two together, with the movable breech-block and its lever, form the gun. In outward appearance the gun looks like a solid steel block about four feet long, pierced with thirty-seven holes. A cartridge holder, consisting of a steel plate with holes corresponding in position with the barrels of the gun, being filled with central-fire cartridges, is inserted in the breech-piece and held in its place by suitable arrangements, whilst by the movement of a handle on the right-hand side of the gun, corresponding plungers are released, and striking their respective cartridges fire the gun. According to the rapidity with which this handle is moved the barrels may be fired one by one, or in a volley. The weight of each projectile is 600 grains, and the charge 115 grains. It would be premature at present to give any results of the experiments now being carried on. It may be here stated that Major Fosbery estimated the speed at which the mitrailleur could be fired at ten rounds per minute, but this rate has not yet been nearly attained in practice.

Steam and Air Engines.—Although the union of steam and air for the purpose of effecting economy in engine working is by no means a new invention, yet the means adopted for effecting this object which have recently been made public, appear to be so far

superior to what has previously been introduced, as to warrant some prominence being given to the subject. Some years ago a steam-engine used in an industrial establishment at Muhlhouse in France, was converted into an aëro-steam engine by the simple addition of a pump to force air into the boiler; a considerable increase of power was stated to have been thereby secured, but its success does not seem to have continued long, and the experiment did not then secure much general favour. Recently, however, the subject has been revived, and two inventors claim the support of the public on behalf of their respective inventions. The first of these is Parker's steam and air engine, and the second Warsop's aëro-steam engine; the general principles involved in each are the same up to a certain point, but the methods of applying them differ considerably. In Parker's engine the air is drawn directly into the steam-pipe, leading from the boiler to the engine, by means of the force of the steam passing through it; this steam-pipe is sometimes passed through a small coke fire, in order to raise the temperature of the united steam and air, but this is not considered in any way essential to the utility of the apparatus. Experiments made with it are reported to have resulted in considerable economy of fuel combined with increased efficiency of engine power.

Warsop's aëro-steam engine consists in the use of an air-pump, worked either by the steam-engine itself, or by a donkey-engine; this pump takes in cold air which, after being compressed, is forced on through an air-pipe passing through the smoke-box, or some other part of the boiler where heat can be taken up from contact with the waste gases. The highly-heated air passes a self-acting clack-valve into the bottom of the boiling water, and is so distributed by simple mechanical means, that it rises constantly through the water. On rising above, the air is saturated by the steam, and the two together pass on to their duty in the cylinder. From a series of experiments carried out with this engine at Nottingham, it appears that in the amount of useful work done for fuel expended, the advantage rested with the combined steam and air system, as compared with when steam only was employed.

Thames Embankment.—Upwards of eight years have now elapsed since the reclamation of the foreshore of the Thames between Westminster and Blackfriars Bridges was undertaken by the Metropolitan Board of Works. This magnificent boulevard was opened on 13th of July last. It consists of a roadway 100 feet in width throughout, having on the river-side a foot pavement 20 feet wide, and on the opposite side one of 16 feet; the former is edged by a row of trees, planted at intervals of 20 feet. The total amount of land reclaimed is 37¼ acres, of which the carriage-road and footways occupy 19; 8 acres will be converted into ornamental gardens for the public use, and the remaining 10¼ acres pass over to the original

proprietors of the foreshore. From the official description of the Victoria Embankment, it appears that the works and material employed comprise 144,000 cubic yards of excavation, 1,000,000 cubic yards of earth filling, 140,000 cubic yards of concrete, 80,000 cubic yards of brickwork, and 650,000 cubic feet of granite. The total cost of the works has been 1,260,000*l.*, and the amount paid for compensation 450,000*l.* Beneath the roadway lies hidden a portion of the London main sewage system, above which is a subway, behind the embankment wall; on the opposite side, the works of the Metropolitan District Railway have been carried on contemporaneously with the Embankment, and there are four stations, namely, at Westminster, Charing Cross, the Temple, and Blackfriars, accessible direct from the roadway. Communications will no doubt shortly be completed between the Embankment and the several roads leading southwards from the Strand, as without such connections this handsome new boulevard would be deprived of half its value as a means of communication; according to an existing Act of Parliament, however, the right to make such connections is prohibited.

Chatham Dockyard Extension.—For some time past extensive works have been in progress for the extension of Chatham Dockyard. They are being executed upon 380 acres of land, and comprise, amongst other works, the reclamation of a marshy tongue of land known as St. Mary's Island, which was formerly submerged at high water; in addition to which the scheme includes the construction of a series of three extensive docks along the line formerly occupied by St. Mary's Creek, and the erection of workshops. The reclamation of St. Mary's Island has necessitated the erection of a considerable portion of embankment and river-wall, the latter consisting of a brickwork face with concrete backing; the island was then raised, by means of spoil tipped upon it, to a level well above high-water mark. The first basin, next Chatham Reach, has an area of 22 acres; it will be used for repairs, and is furnished on its south side with four large graving docks, the first stone of which was laid on 21st April, 1868. The middle, or factory basin, 20 acres in extent, will be provided with factory buildings on the southern side, including fitting and erecting shops, boiler shops, smithy, foundry, stores, &c.; whilst on the northern side will be the camber for a floating dock, a docking platform, and ten slips for laying up frigates, with the necessary worksheds. The third, or fitting-out basin, into which vessels entering for repairs will pass to be dismantled prior to going into the other basin, or, if leaving, they will be rigged and receive their supplies and stores, is 33 acres in area. The repairing basin, with its graving docks, and the communication with the factory basin, are expected to be opened in April next. The factory basin will probably be opened by the end of 1871, and the works of the other basin are also in a forward state.

Meetings of Societies.

Institution of Mechanical Engineers.—The meeting of this Society was held at Nottingham on the 3rd August last. Amongst the papers read were the following:—"On Self-acting Machinery for Knitting Hosiery by Power," by Mr. Arthur Paget, of Longborough; "On the mode of working Coal in the Midland Counties," by Mr. George Fowler, Manager of the Hucknall Colliery; "Conclusions derived from the Experience of Recent Boiler Explosions," by Mr. E. B. Marten, Chief Engineer of the Midland Boiler Assurance Company; and "On a Self-acting Safety and Fire-extinguishing Valve for Steam-Boilers," by Mr. G. D. Hughes. Space will not admit of our giving a reasonable abstract of all the above papers; we shall therefore confine ourselves to a few remarks on the first and last two mentioned subjects. Mr. Fowler's lectures are reviewed elsewhere.

Self-acting Machinery for Knitting Hosiery by Power.—The date at which appliances for knitting have been brought within the limits of machinery is very recent. It is one of the greatest peculiarities of the hosiery manufacture that it shapes wearing apparel without the intervention of the tailor or of the milliner; thus there exists a necessity that the machines employed should be easily adapted to make articles of very great variety of shape, thickness, and degrees of elasticity. Mr. Paget gave a description of a self-acting power-frame of his own invention, which, on account of its necessarily great complication of parts, it would be impossible to describe without illustrations. A skilful framework knitter with his hand-frame would, it was stated, knit about 5400 stitches per minute; whereas a girl could, on the same work, attend to three of Mr. Paget's self-acting machines, making in the aggregate 40,500 stitches per minute.

Boiler Explosions.—Mr. Marten remarked that from the result of the experience of the last four years, he was enabled to confirm the opinion he previously held, that all boilers, however good in original construction, are liable, in the course of time, to get into bad order and explode. The causes of explosions appear to be three, *viz.*—1. Faults in construction or repair; 2. Faults in working, which creep on insidiously and unnoticed; and 3. Faults which might be seen and guarded against by careful attendants. Nearly all the faults would be detected by periodical examination, which is indeed the only true safeguard against explosions. Each cubic foot of water has the explosive effect of one pound of gunpowder, and the explosion of a boiler assimilates more nearly to that of gunpowder than of any other explosive agent. Mr. Marten enters into some detail regarding the various explosions that have come under

his notice, and sums up with some very excellent rules for the avoidance of such disasters.

Safety-Valve for Steam-Boilers.—This apparatus is intended to serve the double functions of fusible plugs and low-water alarums. An internally loaded valve of spherical form is placed in a steam-chamber, and a pair of steam-pipes connect this chamber with the furnace crown of the boiler. The safety-valve is dead weighted, and should the pressure of steam lift it up, it escapes into the chamber and down the pipes into the furnace. Any over-pressure is thus dealt with, and the motion of a float is made to act in a similar way on the same safety-valve. Another independent safety-valve is adjusted to blow off at a pressure somewhat lower than that at which the dead weight is adjusted.

Liverpool Polytechnic Society.—A very interesting paper was recently read before this Society by Mr. T. B. Thorburn, C.E., Surveyor to the Birkenhead Commissioners, "On the method adopted in Birkenhead for Ventilating Sewers, and carrying away the Gaseous Emanations generated therein." This paper, which it would be impossible to follow in detail, contains an account of the extent of the Birkenhead sewers, and not only states the different ventilators employed, but gives also the cost of constructing them according to the several arrangements adopted.

7. GEOLOGY AND PALÆONTOLOGY.

(Including the Proceedings of the Geological Society and Notices of Recent Geological Works.)

Professor John Phillips, M.A., D.C.L., LL.D., F.R.S. &c.—Few men have by their own labours contributed a larger share to the advancement of scientific knowledge than Professor Phillips, and we are glad to obtain a sketch of his career,* which is probably as full of noble achievements as that of any scientific man we have ever known. Brought very young (by the death of his father) under the care of his uncle, William Smith, originally known as "Strata Smith," and afterwards called "the father of English Geology," he was early led to take delight in the identification of strata by their fossil contents, and accompanied his uncle through the greater part of England during his geological investigations, which resulted in the first geological map of England and Wales. Few men of science have had a more distinguished career. Appointed Keeper of the Yorkshire Philosophical Society's Museum in 1825, that Society grew and flourished under his care, and led in

* 'Geol. Mag.,' vol. vii., 1870, p. 301.

1831 to the establishment of the British Association, of which he became the Assistant General Secretary in 1832, and continued to act in that capacity until 1863. In 1834 he became Professor of King's College and a Fellow of the Royal Society. In 1840 he resigned York Museum, and entered upon the duties of the Geological Survey of England and Wales, to which he contributed Memoirs on the Palæozoic Fossils of Cornwall, Devon, and Somerset, and afterwards on the Malvern Hills, &c. In 1844 he became Professor of Geology in the University of Dublin. In 1849 he was appointed one of Her Majesty's Commissioners to inquire into and report upon the system of ventilation employed in mines. In 1853 he commenced the duties of the Chair of Geology at Oxford, which he has continued to hold ever since the death of Dr. Buckland. In 1859 he was elected President of the Geological Society of London; in 1865, President of the British Association. His various geological works are above seventy in number, and his astronomical and other papers are also very numerous. Besides the York Museum which enjoyed the advantages of Professor Phillips's attention, the present Oxford Museum may be said to have been created by him, and is a model for any city in the world to copy.

Lecture on Volcanoes.—Mr. David Forbes, F.R.S., recently* delivered an interesting lecture at St. George's Hall on Volcanoes. Speaking of the relative energy displayed by volcanic forces in the older geological periods, Mr. Forbes said, "We must bear in mind that we still have volcanoes whose craters, several miles in diameter, send forth at times streams of molten stone forty miles and more in length, or showers of ashes which bury the surface of the ground to a depth of 400 feet below them, and, furthermore, see volcanic mountains and islands literally rising up before our eyes to an elevation of even thousands of feet, in what, geologically speaking, is but a second of time, it does not to me seem at all necessary to assume that such internal or cataclysmic forces were so much more energetic in any other period than at present."

The author believes that sufficient importance has not been given to the effects produced by the cataclysmic action of volcanoes. He points out that all the chief features of the earth's surface are due to the elevatory forces within, and that volcanoes not only form the most lofty mountains in the world, but that the backbone of most of the others is composed of eruptive rocks. It must therefore be admitted that the changes effected in the physical geography of the world have resulted from a combination of two great but most opposite agencies, the internal and external, igneous and aqueous, cataclysmic and uniformitarian; and that all the phenomena of nature result from a combination of one or more forces, the same phenomena, at times, being the result of totally different agencies.

* June 19, 1870.

Mr. Hopkins' Method of Determining the Thickness of the Earth's Crust.—Having been some time since challenged by M. Delaunay,* a distinguished French astronomer and mathematician, the late Mr. Hopkins' friend, Archdeacon Pratt, F.R.S.,† writes in his defence and shows what he conceives to be a flaw in M. Delaunay's objections; namely, that the earth is not a simple shell with a fluid interior always revolving in one plane (in which case he admits there would be no possible objection to M. Delaunay's arguments in favour of a comparatively thin rigid crust and a fluid interior), but that it is ever being disturbed by the forces of precession and nutation; and before the rigid crust and the fluid interior could arrive at a state of equilibrium in one position, the axis would begin to assume a new position, and the fluid interior would again be unconformable in its motion to the external shell; and the earth's motion would again be retarded in a small degree, sufficient to interfere with the axial variations to which the earth is ever subject by the laws of precession and nutation. As science advances it is absolutely imperative that in all these questions our conclusions should be in accord with the laws of chemistry and the known terrestrial conditions, as well as the laws of dynamics.

A New Fossil Snake in Greece.—A new fossil *Python* has been lately described by Dr. Ferd. Roemer ‡ from the Island of Eubæa. This is the second fossil ophidian found in Greece, and adds greatly to the interest of the Miocene fauna of this old continent, already rendered so important by the discoveries at Pikermi of such a remarkable series of types of African Mammalia, together with the *Hipparion* by M. Gaudry.

A New Labyrinthodont Amphibian from the Coal-shale near Newcastle-upon-Tyne.—Mr. Thomas Atthey, well known to geologists as one of the most indefatigable investigators of the fossil-remains of the Newcastle Coal-shales, has again been successful in bringing to light the skull of a new and remarkable Labyrinthodont reptile, which the authors of the paper,§ Messrs. Atthey and Hancock, have named *Batrachiderpeton lineatum.* The lower jaw was discovered three or four years since, but the cranium has only now been obtained.

It is impossible to contemplate the structure of the roof of the mouth of this curious Labyrinthodont, without being reminded of the arrangement of the parts in that of *Siren, Proteus,* and *Axolotl.* The well-armed vomer in particular is very striking. The extensive development of this vomerine armature and the deficiency of bony maxillæ, would seem to ally *Batrachiderpeton*

* 'Geol. Mag.,' vol. v., p. 507. † Ibid., vol. vii., p. 421.

‡ 'Abdruck a. d. Zeitschr. d. Deutschen Geologischen Gesellschaft,' Jahrg, 1870.

§ 'Ann. and Mag. Nat. Hist.,' Series 4, vol. vi., No. 31, p. 56, Pl. I., July, 1870.

to *Siren* and *Proteus;* while the relationship of the vomers to the pterygoids, and the form of the latter, are very similar to what obtains in *Axolotl;* and the alliance with this last-named interesting form would be rendered still stronger, if it should turn out that our new genus has really bony maxillæ, particularly as the premaxillæ are armed with teeth. In *Siren* and *Proteus* the premaxillaries are quite minute and are devoid of teeth. This is not the only instance in which a Labyrinthodont has been found to exhibit an approximation to the *Siren*-type of structure. *Pteroplax* is so related, although its approach is by a different line from that of *Batrachiderpeton.*

Petrified Forest near Cairo.—The fossil-wood which covers the desert to the east of Cairo has long filled the passing traveller on this great eastern high road with surprise. The immense quantity of what seems to be decaying wood in a region described as a "dreary arid expanse, treeless and almost shrubless, rugged with dark-coloured knolls, and intersected by a few dry rain-channels," excites, by the remarkable contrast of the present with what is apparently the not far-distant past, the wonder of the most careless observer. They have, of course, been referred to by travellers in many published books. Burkhardt thought they were petrified date-trees, Holroyd referred them to the Doom-palm, Murray's 'Handbook' also speaks of them as palms. Gardiner Wilkinson refers to branched and thorn-bearing trees as well as palms, also to some jointed stems resembling bamboos. A careful examination by the late Prof. Unger, however, failed to elicit more than a single species, after a most searching examination of a very large series of specimens, and after a personal visit to the spot.

This form, which he named *Nicolia Egyptiaca,* has just been supplemented by a second species brought home by Prof. Owen during his recent visit to Egypt with the Prince and Princess of Wales. Mr. Carruthers has figured and described it as *Nicolia Owenii,** after its discoverer.

Italian Tertiary Brachiopoda.—Mr. Thomas Davidson, F.R.S., our great authority upon "Lamp-shells," has taken up his pen and crayons to illustrate the Tertiary Brachiopoda of Italy, which he is carrying out most completely in the 'Geological Magazine.' In his introduction he refers to the much-discussed question of development of species. "We are," he says, "far from having discovered the laws which regulate the gradual succession of life; and we are, I fear, much too apt to guess at the origin of species, and to interpret those unknown laws from a small number of incomplete observations. The assiduous researches which, for many years, I have made among the living and fossil species of Brachiopoda have, to a certain extent, imbued my mind with the idea that an indivi-

* See 'Geol. Mag.,' vol. vii., p. 306, 1870.

dual species may have been gradually very much modified in time, so as to suit the conditions under which it had to exist; but at the same time everyone who has studied with any degree of care any class composing the animal kingdom, must frankly admit that there are so many inexplicable sudden appearances of entirely distinct forms, with no apparent links connecting them with those that were antecedent or even contemporaneous, that it is impossible to arrive at any definite conclusions as to what extent species are derived from their predecessors."

New British Brachiopod.—Mr. E. Ray Lankester describes a new species of *Terebratula* from the (Portlandian ?) "Drift" of East Anglia, which he has named *T. rex*; it is a remarkably large form.

Cephalaspis Dawsoni, sp. nov.—The same gentleman describes a nearly perfect Cephalaspidean Fish from the Silurio-Devonian beds on the north side of Gaspé Bay, Canada, associated with plant-remains. It is named after Principal Dawson, of Montreal.

The Structure of the Crinoidea, Cystidea, and Blastoidea.—We have lately received considerable additional information upon this subject from the pen of Mr. E. Billings, the able Palæontologist to the Geological Survey of Canada.* In the first part of his paper Mr. Billings considers the position of the mouth in relation to the ambulacral system.

Earlier palæontologists described the large lateral aperture in the Cystidea as the mouth. Von Buch, Forbes, Hall, and Billings himself, in his first paper, adopted the view that this was not the mouth, but an ovarian aperture, and that the smaller orifice, usually situated in the apex, from which the ambulacral grooves radiate, was the true oral orifice. Subsequently (in 1858) Mr. Billings re-investigated the subject, and came to the conclusion that the lateral aperture was really the mouth, or serving as both oral and anal aperture in those species not possessing distinct orifices. The small apical orifice was determined to be an ambulacral aperture.

To this view Prof. Wyville Thomson demurs, on the ground of the want of analogy in the rest of the class. Mr. Billings replies that in this class the position of the various organs in relation to each other, and also to the general mass of the body, is subject to very great fluctuations. Thus the mouth and vent are separated in some of the groups, but united in others; while either or both may open out to the surface directly upward or downward, or at any lateral point. The ovaries may be either dorsal or ventral, internal or external, and associated with either the mouth or the anus, or with neither. The ambulacral skeleton may be imbedded in and form a portion of the general covering of the body, or lie upon the surface, or be borne upon free-moving arms. Although these characters are constant, or nearly so, in the same family, in

* See Silliman's 'American Journal of Science.'

different orders, or remotely allied families, they are extremely variable.

The author proceeds to cite a number of instances in support of his conclusions in which the mouth was altogether disconnected from the radial system, and he figures *Batocrinus icosidactylus*, *Amphoracrinus*, sp. *Caryocrinus ornatus*, &c.

Mr. Billings next discusses the functions of the pectinated rhombs and calycine pores of the Cystidea. Upon this subject a very able and exhaustive paper was written by Mr. J. Rofe,* to which Mr. Billings refers, and accepts the decision of Dr. Dana, Mr. Rofe, &c., and concludes them to be respiratory organs. The author proceeds to describe these organs in *Codaster*, *Pentremites*, &c., and then endeavours to show the homologies which exist between the respiratory organs of these palæozoic forms and recent Echinoderms, and lastly, the nature of the "convoluted plate" of the Crinoidea. This plate, like the pectinated rhombs, seems to have been connected with the respiratory system. There can be no doubt that the true explanation of why these respiratory organs occupy so large a proportion of the body of the animal is to be found in the fact that the food was obtained by the motion of the vibratile cilia of the arms, which thus fulfilled, as in so many other invertebrates, the double function of bringing fresh streams of the circumambient respiratory medium into intimate contact with the fluid within the general cavity of the body of the animal; and at the same time of conveying minute animalculæ and other organic particles to the mouth in order to serve as food.

Geological Society of London.

The present number of the 'Proceedings of the Geological Society' contains a rich store of palæontological information, both British and foreign. We have illustrations of Mammalia, Reptilia, Mollusca, Corals, and Plants; and those who delight in long lists of fossils can also fully satisfy their appetites. Nor need the field-geologist grumble, for he also may regale himself on the Neocomian, the Oolite, or the Lias to his heart's content. A valuable contribution to our knowledge of Fossil Corals is from Dr. P. Martin Duncan, "On the Madreporaria of the Australian Tertiary Deposits." The series described is from the province of Victoria, the Geological Survey of which was (until lately abolished) so ably conducted by Mr. Selwyn (now Director of the Geological Survey of Canada). The species described do not belong to the reef-building forms, but to such as now occupy the sea-bottom from low spring-tide mark to the depth where Polyzoa abound. It is interesting to

* 'Geol. Mag.,' 1865, vol. ii., p. 245.

note that twenty genera are now found in the Australian seas, only three of which, however, have species in the Tertiaries, *viz.* the cosmopolite *Trochocyathus*, *Flabellum*, and *Amphihelia*, but the fossil species are quite distinct from those now living. If we may judge by the wide geographical distribution of some of these species we may with safety infer that their range in time was also very much greater than has hitherto been assumed. Allied forms are found living in Japan and China, the Red Sea, the West Indies, and Europe in Miocene times.

The descriptions of the new species are illustrated by thirty-two figures, occupying three double-octavo plates.

There is reason to believe that the Wealden vertebra, now described and figured by Mr. J. W. Hulke, belongs to the same large animal—distinct from any of the known *Dinosaurs*—of which there is a single vertebra preserved in the British Museum, and named by the late Dr. Mantell *Streptospondylus*. The texture of the bone is like the coarse diploë of the elephant's skull, and has led to the belief, by Mr. H. G. Seeley, that it represents a gigantic Pterosaurian; but Mr. Hulke reminds us that an extremely light skeleton does not necessarily prove endowment with flight, and also that all the known flying-reptiles have procœlian vertebræ, whilst the vertebra of *Streptospondylus* is amphicœlian in type. The supply of new and wonderful reptilian remains furnished by the Wealden of the Isle of Wight seems almost inexhaustible, but it is much to be regretted that by far the greater part of these have, of late years, fallen into the hands of a local collector in the island, unable to describe them himself and unwilling to allow them to be worked out and described by anyone else.

Our knowledge of Fossil Botany has been increased by an interesting description of a new fossil fern-stem, so like the recent *Osmunda*, as to justify its describer, Mr. Carruthers, in placing it in the Osmundaceæ. The specimen was silicified so effectually that even the starch-grains in its cells, and the mycelium of a fungus traversing some of them, were perfectly represented. The fossil (which was probably derived from the upper part of the Thanet Sands) has been named *Osmundites Dowkeri*, after Mr. George Dowker, its discoverer.

Professor Owen has ventured upon the difficult task of determining the remains of a number of fossil Mammalia upon the evidence furnished by a series of detached teeth brought home by Mr. Robert Swinhoe, H.B.M. Consul at Formosa, and obtained by him from the apothecaries' shops at Shanghai and at Chung-king-foo (Eastern Szechuen) on the Yangtse-kiang River. They included two species of *Stegodon*, a new *Hyæna*, a new Tapir, a new *Rhinoceros*, and a species of Kaup's genus *Chalicotherium*. From a general agreement in colour, chemical condition, &c., Professor Owen

concluded they all belonged to one and the same period, either to Upper Pliocene or Post Pliocene. Strong objections were raised as to the soundness of the species by Professor Busk, especially to *Stegodon*, *Hyæna*, and *Rhinoceros*; it was also objected by Professor Boyd Dawkins, that there was no proof of their contemporaneity. These teeth, which are extremely various, are sold by the Chinese apothecaries as a very valuable medicine when pounded to a powder. They are described by Mr. Daniel Hanbury in his account of the Chinese Materia Medica.

Mr. Hanbury mentions that Mr. Waterhouse, of the British Museum, has determined the following species:—Molars of the lower jaw of *Rhinoceros tichorhinus*, tooth of *Mastodon*; of *Elephas insignis* (?); molars of *Equus*; teeth of *Hippotherium* (two species?); teeth of sheep, stag, bear.*

They are said to come from the provinces of Shen-si and Shan-si, but the demand for them is so great that they are believed to be largely imported from the East Indies, and notably from Borneo.

Mr. Sharp's paper, "On the Oolites of Northampton," is principally of importance because of the recent discovery in this district of vast bands of ironstone, the economic quarrying of which has yielded a characteristic fauna with a decidedly *Inferior Oolite* facies, in beds which had been mapped as Great Oolite ("Northampton Sands") by the Geological Survey, and in which—until quite recently—not a trace of a fossil remain was known to exist.

Mr. Sharp has carefully described the district illustrating his observations by numerous sections and a good sketch-map of its geology, together with lists and localities of the fossils he has been so successful in obtaining. As a rider to the paper, Dr. Wright describes a new and very finely-preserved star-fish (*Stellaster Sharpii*), from the ironstone of the Inferior Oolite, Northampton.

Mr. J. W. Judd, of the Geological Survey of England and Wales, has devoted much time and attention to the Neocomian strata of Lincolnshire and Yorkshire and their correlation with those of north-western Germany and elsewhere. He now gives us the result of his studies, carefully prepared and illustrated with maps, sections, and tables. The Neocomian beds of Yorkshire, &c., appear to be the extreme westerly development of a great mass of strata of the same age stretching over a wide area in Northern Europe. It is also seen that in Yorkshire and in Brunswick the Neocomian series is complete, but in the intermediate districts its lowest member is absent, being replaced by the fresh-water deposits of the German Wealden.

Mr. Ralph Tate supplies two papers, on the Middle Lias in Ireland, and the Lower and Middle Lias in Gloucestershire. No higher member of the Jurassic series is known in Ireland than the

* 'Journal of the Pharmaceutical Society,' 1860.

Lower Lias. The Middle Lias occurs as drift on cultivated fields, &c. Mr. Tate suggests that this drift may have been transported from the Hebrides by glacial action. In the case of Gloucestershire, Mr. Tate endeavoured to apply the numerical test as to the distribution of organic remains in order to show that the zone of *Ammonites Jamesoni* belongs to the Middle Lias, and *A. raricostatus* to the Lower Lias. For the present it is exceedingly difficult to follow these minute divisions until more of their contained fossils have been identified and figured.

In addition to these, we have abstract notices of the Crag of Norfolk and Associated Beds, by J. Prestwich, Esq., F.R.S. Captain S. Hyde on Deep-mining in S.W. Ireland. Dr. E. Bunzel on a Reptilian Skull from Grünbach. Mr. R. J. Lechmere Guppy on Trinidad Fossils. M. Coumbary on the Fall of an Aerolite in Fezzan. Dr. A. A. Caruana on a further discovery of Fossil Elephants in Malta. The Journal is a very stout one, numbering 468 pp. and having fourteen lithographic plates.

8. METEOROLOGY.

The Meteorological Office has issued Part I. of its new publication, 'The Quarterly Weather Report,' for the first three months of 1869. The chief features of novelty presented by this Report are the *fac-simile* representations of the curves of the self-recording instruments. It should be stated that the preparation of plates such as those referred to has been rendered possible by an invention of Mr. Francis Galton's. This is a pantagraph which is capable of effecting reductions simultaneously in different proportions along two rectangular co-ordinates. The proportions selected for the plates have been $\frac{1}{6}$ for the horizontal or time scale, and $\frac{1}{2}$ for the vertical scale. By this means all the information for five days from the seven observatories is condensed into the space of two 4to plates, one for the barograms and wet and dry bulb thermograms, the other for the wind and rain. Scales on both the British and metrical systems are given at each side, so that the readings of the barometers and thermometers may be determined for any epoch. For the wind the scales are in statute and geographical miles.

The letter-press consists of (1) an introduction containing some general remarks, especially on the difficulty of obtaining trustworthy records of wind at land stations; (2) the Report itself, which is a chronicle of the weather for the three months, derived from all sources which were available to the office, with tabular statistics of storms; (3) the tables for the year 1869, giving the monthly and the five-day means of various elements, derived from the hourly tabulated readings of the instruments.

In the appendix Mr. Scott has given a notice of some late easterly storms, which is an attempt to classify them and possibly discover traces of their origin. The number of storms investigated is only twenty-five, evidently far too few to allow of important deductions being drawn, but some very interesting facts come out in the discussion, and we hope that the paper may be followed by others of a similar statistical character.

The price of the Report is very moderate, being only 5*s.* a number. It is published by Stanford.

The Third Annual Report of the Committee has also lately appeared. It shows steady progress in the three departments of the operations of the office—Ocean Meteorology, Storm Warnings, and Land Meteorology of these islands. With regard to the last of these we regret to see that Dr. Stewart has found himself obliged to resign his position as Secretary to the Committee. His services in organizing the system of self-recording observation has been of extreme value to the cause of meteorology in England.

In Part II. of the Report we have the description of some new instruments—Mr. Galton's Pantagraph, above noticed; Beckley's Self-registering Rain-gauge, which is to be introduced at all the observatories; and Dr. Miller's Deep-sea Thermometer, to which we have alluded in a previous number.

The last number of the 'Journal of the Scottish Meteorological Society' is mainly occupied with a paper by Mr. D. Milne Home, "Suggestions for Increasing the Supply of Spring Water at Malta, &c." In our notice of the last paper by the same author, in No. XXV. of this Journal, we said, "The paper consists of a series of extracts from the reports of various observers," and the same words will apply exactly to that now under consideration. Mr. Home in his remarks suggests the old and well-known remedy for local drought, *viz.* extensive plantations. It seems rather a pity that when the Society, as we learn from another part of the journal, is endeavouring to obtain funds from the Government, any portion of its means should be expended in publishing papers on foreign, or at least colonial, meteorology.

In our last number we noticed Dr. R. Angus Smith's paper "On the Detection and Estimation of the Impurities of Air, by the Analysis of Rain Water, and by Washing Bottles of Air." His Sixth Report, as Alkali Inspector under the Board of Trade, has just appeared, and contains much valuable information on the subject, which is, however, too foreign to meteorology to require further notice here.

Mr. Blanford, Meteorological Reporter to the Government of Bengal, has published a paper in the 'Journal of the Asiatic Society,' "On the Relations of Irregularities of Barometrical Pressure to the Monsoon Rainfall of 1868–9." He finds that in both

years an area of relative depression existed in Lower Bengal which took its rise at the beginning of the south-west monsoon in April. "Its position was different in the two years, being in the former in the north-west corner of the Bay of Bengal, in the latter in the hilly country to the west of the Delta. It influenced the vapour-bearing winds from the south by deflecting them towards it; and necessarily, by determining an ascending current, it produced an excessive rainfall to the north of its position, the maximum fall being at from 50 to 150 miles distance from the place where the barometer was lowest. Finally, it impeded the passage of the vapour-bearing winds to the north-west provinces, and thus deprived that region of a great part of its usual annual supply."

Considering the extreme importance to India of the periodical rainfall, papers like this of Mr. Blanford's are of great value and interest.

The Third Annual Report of Mr. Blanford's office has also appeared; it shows a steady progress in the way of systematic organization of the various observing stations in Bengal. We may now hope that the example shown by this Presidency will soon be followed in the other districts of Hindostan.

M. Harold Tarry has published notices of the fall of red rain in Italy on various occasions. The papers first appeared in the 'Bulletin of the Association Scientifique,' and then in the 'Comptes Rendus.' His object is to prove that the occurrence is due to previous dust-storms in the desert of Sahara, and not to the advent of cosmical dust from the regions of space, as Arago and Quetelet formerly maintained. He has examined three recent instances of the phenomenon, *viz.* March 10, 1869, March 24, 1869, February 14, 1870. He says that the sequence of circumstances is the same in all cases. A barometrical depression and a storm advances from north to south across western Europe to Africa, where the sand of the Sahara is set in motion in clouds of dust. A few days subsequently a reverse action takes place: a storm advances from Africa to the south of Europe, carrying the dust with it, which comes to the earth with the rain.

The paper is very interesting, but we must say that M. Tarry has not quite proved his case as yet.

The later numbers of the 'Journal of the Austrian Meteorological Society' do not contain much that is suitable for extraction for this Chronicle. The editors have adopted the practice of giving abstracts of meteorological data from isolated stations, and these cannot be rendered intelligible without the insertion of a large amount of tabular matter. The districts for which such information is afforded are very various. M. Rayet's paper "On the Meteorology of the Isthmus of Suez" is reproduced, in abstract, from the 'Atlas Météorologique' for 1868. Then follow several papers by M. Wojeikoff "On the Meteorology of Russia," which he

has compiled from various disconnected registers of local observations for short periods lying at the observatory of St. Petersburgh. The stations are very widely distributed over Europe and Asia.

The Report of the Central Physical Observatory, by Prof. H. Wild, the Director, consists mainly of an account of the condition of the observatory, and a catalogue and description of instruments. As no report had been published since 1864 it was necessary to take stock, and to publish the account for the information of the Russian public. The only matter of general interest is that Prof. Wild appears to have finally decided not to employ photographic self-recording instruments at the normal stations, owing to their serious initial cost and the expense and trouble of working them.

Dr. Prestel, of Emden, has published a pamphlet entitled 'Der Sturmwarner,' in which he commences by discussing the facts of storms, and the possibility of giving telegraphic intelligence of their approach. On reading this part of the paper we are disappointed to find that Dr. Prestel has not made himself acquainted with the latest facts of the subject. The principle of his storm-warner is similar to that of Piddington's horn circles.

He makes four assumptions.

I. That the barometrical reading at the centre of the storm is 28·78 ins. on the mean.

II. That the wind blows in circles round it.

III. That the diameter of the storm is nearly constant.

IV. That the difference between barometrical readings for a given distance in all parts of the storm, or the "gradient," is constant.

If these four postulates be granted, the use of the transparent diagram is perfectly simple and intelligible, but as there is no foundation for any one of them, the whole reasoning falls to the ground.

Another book the utility of which we fail to discover, although it has been favourably noticed in some newspapers, is 'The Wind in his Circuits,' by Lieut. R. H. Armit, R.N.

The author proposes to subvert Maury's theory of the wind by facts drawn from his own experience. A few examples will suffice to show the character of his arguments. The italics are his:—

"The trade winds are very damp moist winds, heavily charged with vapour: every cubic inch of them containing millions upon millions of minute globules of water. On entering the equatorial calm belt, the process these globules undergo is simply that of being turned into *steam*."*

"The easterly wind is formed *of compressed vapour or steam*."†

"Lightning and thunder are caused by the 'Arctic current' *descending* to fill any vacuum that may suddenly be formed in the warm currents below it. . . . . . The 'Arctic current' in *rushing down* would grate against the sides of the warm air of the under

* P. 24. † P. 57.

currents, causing '*friction*' and '*lightning*,' the sudden shock of the *impenetrable masses the* '*thunder.*'"*

"Regarding our atmosphere as a homogeneous metallic body."†

Our readers will be ready to admit that Capt. Maury has not much to fear from opponents like Mr. Armit.

We are glad, however, to be able to record a contribution to theoretical meteorology of a character very different to the foregoing. This is 'Physical Geography in its relation to the Prevailing Winds and Currents,' by Mr. J. Knox Laughton. We regret that we can only very briefly allude to its contents. Mr. Laughton gives a concise account of the existing winds, and then discusses the accepted theories of the origin of the great currents of air and water which exist on the globe. He shows that Hadley's theory of the trade winds, as developed by Dove, is insufficient to explain the facts observed. The air does not flow towards the region of highest temperature for the time being. In the old continent this district is the north of Africa and Arabia, towards which the trade wind does not blow. Secondly, he concludes that the rotation of the earth does not materially affect the direction of the currents of air, because "the friction between the air and earth is so great, that the air almost instantaneously acquires the velocity of the points of the earth to which it is transplanted," and because Dove's theory will not explain due easterly or westerly winds any more than north-westerly or south-easterly winds in the northern hemisphere (S.W. or N.E. in the southern). The laws of motion of flowing water are next described, and the action of obstacles in altering the direction of the current, and producing reverse currents or *backwaters*. After giving an account of the currents of the sea, similar to that previously given of the winds, the author concludes "that *wind*, acting not only on the surface of the sea, but, by means of intense friction, to a considerable depth, is the chief"—he will not say the only—"cause of the numerous oceanic currents."

The final theory which Mr. Laughton adopts is thus stated:—"The whole atmosphere, relatively to the surface of the earth, continually moves, or tends to move from west to east; and the prevalent local variations from that direction are either eddies, or deflections, formed in accordance with the principles which regulate the motion of fluids."

Our space will not allow of our criticizing Mr. Laughton's reasoning in detail, but we cannot omit to give him credit for having collected a most valuable series of facts from the most authentic and most recent sources, and discussed them with thorough conscientiousness. Although we may not agree with all his conclusions, we feel that he has produced a very useful and interesting work.

* P. 68. † P. 112.

9. MINERALOGY.

While the colony of Victoria has year after year been eagerly explored by many a miner in quest of its golden wealth, it is notable that the number of mineral species hitherto brought to light has been strangely incommensurate with the activity of these mining operations. In spite, however, of this poverty of materials—a poverty which is the more striking when contrasted with the prodigality of species distributed through the ore-deposits of many other mining countries—some good mineralogical work has already been done in the colony. This is due especially to the exertions of Mr. Ulrich, one of the geologists who, under Mr. Selwyn's guidance, were carefully working out the structure of the country, until the colonists were tempted, in an evil hour, to disband their staff of Geological Surveyors. Mr. Ulrich's recent observations on the minerals of Victoria have been thrown into the form of a little *brochure*,* which may be regarded as forming a sequel to an essay on a kindred subject prepared by the author for the Intercolonial Exhibition of 1867.

In the pamphlet now before us we find descriptions of three species which are entirely new to mineralogical science. One of these is a native alloy of gold and bismuth found in the Nuggetty Reef at Maldon, and hence termed *Maldonite*;† the second is a green massive mineral allied to serpentine, consisting of a hydrous silicate of alumina and sesquioxide of chromium, found in Upper Silurian rocks on the flanks of the Mount Ida range, and named *Selwynite*, in compliment to the Director of the late Geological Survey; while the third new species is *Talcosite*, a mineral which resembles talc and occurs in seams traversing the Selwynite. In addition to these newly-discovered species, many other Victorian minerals described by Mr. Ulrich merit attention, either from their crystalline forms—such as the splendid specimens of Herschelite examined several years ago by Dr. von Lang, of which some additional forms have been lately discovered—or from their peculiar mode of occurrence, such as the crystals of Struvite recently found in the guano which covers the floor of the Skipton caves in Ballarat, and appears to have been derived in great measure from the excrement of bats which resort to the caverns as a hiding-place during the day. Among gem-stones, Victoria can boast of possessing the diamond, ruby, sapphire, topaz, and garnet—some crystals of the last being notable for their singularly distorted and consequently deceptive appearance. The study of Australian gems is one which the Rev. Dr. Bleasdale has made peculiarly his own.

* 'Contributions to the Mineralogy of Victoria.' By George H. F. Ulrich, F.G.S. Melbourne, 1870. Pp. 32.

† 'Quart. Journ. Science,' October, 1869, p. 556.

Passing to another of our colonies, we find materials for mineralogical work afforded by the many meteorites which from time to time have fallen in India. One of these has lately been analyzed by Mr Waldie.* In February, 1867, a shower of about forty stones fell near Khettree in Rajpootana. Alarmed at the shower, and attributing it to the vengeance of an offended deity, the natives at once collected the stones, reduced them to a fine powder, and scattered it to the breeze. Diligent search, however, led to the discovery of a piece which luckily had escaped destruction, and it is this fragment which formed the subject of Mr. Waldie's analysis. The stone is of a light bluish-grey colour, darker in parts, and contains disseminated metallic particles and granules of a greenish-yellow colour. Its general composition was found to be as follows:—

Nickel iron	18·55
Troilite and schreibersite	5·22
Earthy matter soluble in acids	35·18
Ditto insoluble	42·36
	101·31

For eighty years a specimen has lain in the Würzburg collection, under the name of an arsenical ore. Prof. Sandberger's recent examination shows, however, that it is really a new species, which he terms *Isoclase*.† The mineral—which is said to have come from the mines of Joachimsthal, in Bohemia—crystallizes in the oblique system, and consists of a hydrous phosphate of lime having the following formula, and therefore analogous to the species Libethenite and Tagilite, among the copper phosphates: $4\,CaO.PO_5 + 5\,HO$.

Another new phosphate of lime is described by the same author under the name of *Collophane.* This is an amorphous substance found in cavities in the altered coralline rock of Sombrero, and has the following composition: $3\,CaO.PO_5 + HO$.

The energetic French chemist, M. Pisani, has published an analysis of the new Algerian mineral described by M. Flajolot as *Nadorite*—a name which has reference to the Djebel Nador, in the province of Constantine, where the mineral in question was found. While Flajolot regarded it as a compound of the oxides of lead and antimony, Pisani finds that it contains chlorine—a point of great interest, since this is the first mineral in which chlorine has been detected in a compound containing antimony. In fact, Nadorite is an antimonial Mendipite, or oxychloride of lead, and may be thus formulated:‡ $(Sb_2O_3.PbO) + PbCl$.

Rabdionite is Von Kobell's name for a new mineral from the

* 'Chemical News,' xxi., No. 551, p. 278.
† Leonhard and Bronn's 'Jahrbuch für Mineralogie,' 1870, Heft III., p. 306.
‡ 'Comptes Rendus,' Aug. 1, 1870, p. 319.

mines of Nischne Tagilsk, in the Urals.* It occurs in small dull black rods, and contains in a hydrated form the protoxides of copper, manganese, and cobalt, with the peroxides of iron and manganese. In writing the name of this species we have followed the author's mode of orthography, but the etymology of the word clearly demands the form *Rhabdionite* (ῥαβδίον, diminutive of ῥάβδος, a rod).

Hermann publishes the results of his examination of the Russian mineral *Lawrowite*,† which tend to show that it is really a diopside, coloured bright green by the presence of 4·2 per cent. of hypovanadate of lime. Accompanying this mineral, he finds a new species of analogous composition, but containing much more vanadium. This species, which he proposes to name *Vanadiolite*, may be regarded as formed of three molecules of augite associated with one of hypovanadate of lime. The same author describes, under the term *Phosphorchromite*, a Russian mineral containing chromate of lead and phosphate of copper.

A new British locality is announced for the beautiful mineral *avanturine-quartz*.‡ Mr. Traill is said to have found it in Orkney, on the S. and S.W. shores of Inganess Bay.

According to the 'Brighton Herald,' a large deposit of the subsulphate of alumina, called *Websterite*, has been recently found in Brighton during certain excavations for deep drainage.

Professor Streng's recently-published 'Mineralogical Notices'§ describe the prehnite of Harzburg, and certain pseudomorphs of calcite and asbestos, after apophyllite, also from Harzburg.

The attention of the crystallographer may be directed to Dr. Werner's paper "On the Theory of the Hexagonal System;" ‖ to Dr. Klein's 'Note on some Forms of Galena;'¶ and to Herr Groth's 'Dissertation on the Topaz of certain Tin-ore Deposits, especially those of Altenberg and Schlaggenwald, in Bohemia.'**

10. MINING AND METALLURGY.

Mining.

In our Chronicles for July we noticed the proposed amalgamation of the *Mines Regulation Bill* and the *Metalliferous Mines Bill*, remarking on the unfortunate character of this attempt to legislate by one Act for two dangerous industries, differing in all their essential

* 'Journ. f. prakt. Chimie,' 1870, p. 423. † Ibid., p. 442.
‡ 'Geolog. Mag.,' Sept., 1870, p. 444.
§ Leonhard and Bronn's 'Jahrbuch,' 1870, Heft III., p. 314.
‖ Ibid., p. 290. ¶ Ibid., p. 311.
** 'Zeitschr. d. d. geolog. Gesell.,' XXII., p. 381.

Erratum in Chronicles last quarter, p. 417, line 8 from bottom: *for* "the several species," *read* "the several plagioclastic species."

points (except that they are both subterranean employments) as widely as possible from each other.

We have much pleasure in recording the fact that this amalgamated Bill has been withdrawn. The attention of the House of Commons will no doubt be called early in the next session to some system of legislation for collieries and mines. Let us hope that any Bills which may be framed, will be submitted to some persons familiar with the perils of mining, who may so organize the rules as to render them effective and beneficial.

The Colliery Inspectors have recently issued their reports of the fatal accidents and deaths in and about the coal and ironstone mines of Great Britain during the year 1869. The following is a condensed summary of their tabular statement of accidents in collieries:

	Explosions.		Falls in Mines.		In Shafts.		Miscellaneous. Underground.		Miscellaneous. On Surface.	
	Accidents.	Deaths.	Accidents.	Deaths.	Accidents.	Deaths.	Accidents.	Deaths.	Accidents.	Deaths.
1. Northumberland, Cumberland, and North Durham	2	6	26	28	14	14	18	18	12	14
2. South Durham ..	1	2	30	31	6	6	24	25	13	15
3. North and East Lancashire	3	3	39	39	11	12	14	15	7	7
4. West Lancashire and North Wales	8	128	43	45	20	20	21	32	9	9
5. Yorkshire	1	1	38	41	6	7	12	15	5	5
6. Derbyshire, Nottinghamshire, Leicestershire, Warwickshire	5	6	31	31	11	12	19	22	4	7
7. North Staffordshire, Chester, Shropshire	3	7	25	25	7	7	9	10	1	1
8. South Staffordshire, Worcestershire	5	6	63	68	20	22	6	6	2	2
9. Monmouthshire, Gloucestershire, Somersetshire	6	23	37	37	..	..	5	5	3	3
10. South Wales	9	70	62	63	14	15	21	21	9	12
11. Scotland—East ..	1	1	29	30	8	8	10	10	7	9
12. Scotland—West ..	4	4	28	28	6	6	..	..	1	1
Total in Collieries ..	48	257	451	466	123	129	159	179	73	85
„ Ironstone Mines	..	..	29	29	12	12	10	10	3	3
Gross Total	48	257	480	495	135	141	169	189	76	88

Total fatal accidents .. .. 908 in 1869 .. 928 in 1868
Total deaths .. .. 1170 „ .. 1080 „

In July we stated that tin mining in our western counties had resumed a condition of high prosperity. This has, unfortunately,

been exceedingly short lived. The influence of the Continental war has led to a reduction of from 12*l.* to 15*l.* a ton in the price of tin ore, and consequently the tin miner is dispirited, and tin mines are not at all in favour with speculators.

The following were the purchases of tin ore in each month of 1869:—

	Tons.		Tons.
January	1,203	July	1,138
February	1,291	August	1,291
March	976	September	1,144
April	1,613	October	1,178
May	1,223	November	1,279
June	1,277	December	1,112
		Total for 1869	14,725

Some interesting mining operations are now being prosecuted at a colliery belonging to the Earl of Dudley. We copy the following particulars from the 'Birmingham Gazette:'—This section of the Dudley estate has probably been the most prolific in the world so far as the actual yield of coal is concerned. It has been in work for more than a hundred years, and yet its resources hold out satisfactory promises of reward to the persevering efforts of those engaged in the present experiment. In some parts of the district on the east side of Dudley, coal is not to be found until the mine reaches a depth of 250 yards; in other parts, as in the celebrated twelve-yard-thick measure at Fox-yards, near Sedgeley, the coal crops out at the surface, and may be carted away for almost the cost of loading. In most cases the coal lies in a pretty nearly level condition, and may be worked in the ordinary way, *viz.* by a pit-shaft sunk perpendicularly into the earth, from the bottom of which "gate roads" are driven; but in some instances the coal lies in such an oblique position that to "win" it in that manner involves great cost and danger. To overcome the difficulties of getting the coal where it lies in this oblique position, the experiment under notice has been resorted to. It consists of two tunnels driven from the surface of the earth into the mine, at an angle of about thirty degrees; these tunnels are lined with substantial brickwork, and the "skips" and their contents are drawn up the inclined railway, which is laid down for the purpose, by an ordinary stationary engine fixed on the surface. The coal already got in this way is only a few yards from the surface, and it is found to be of a good serviceable quality. Similar experiments were made near Bilston twelve months ago, and the works are now in successful operation there.

The discovery of a coal of good quality in Japan is of moment. This Japanese coal has been discovered in the Takasima Colliery at Nagasaki. According to the analysis of Dr. Jas. Martin, the constituents of this coal are in the following proportions:—Carbon,

82·07; hydrogen, 5·30; oxygen, 3·35; nitrogen, 2·72; sulphur, 1·64; ash, 4·90; loss, 0·02. The samples taken from the level drives, showing a specific gravity of 1·231, are scarcely less satisfactory. On first firing up, the coal is said to give out smoke rather freely, but this soon passes off, and its deposits of soot are not more than would accrue from good English coal. The following remarks of Mr. Madden, chief engineer of Her Majesty's ship 'Ocean,' are very conclusive as to its merits:—"Keeping steam with ease at 50 lbs. pressure. Full speed for five hours with a continuous steam exhaust blast from four cylinders, being a very severe test of evaporative qualities for bituminous coal, which involves large quantities of smoke each firing for a short time, but if used in ordinary boilers, without blast and slow combustion this would be considerably reduced. I consider the two samples as tested above to be equal in general steaming properties to English North Country; and compared with Welsh, repeatedly tested under same circumstances, as shown to be best Welsh 5 cwt. = 7 cwt. Takasima."

We have recently visited the Hayle Foundry Wharf at Nine Elms to see the operation of some pneumatic stamps. The importance of introducing the utmost economy into the ore-dressing arrangements of the tin mines of Cornwall renders this invention of the highest importance. The following is a brief description of the machine:—

In the pneumatic stamp the motion is conveyed from the crank to cap and guide cross-head, on piston-rod, by an ordinary connecting-rod. Attached to its lower end is the piston-rod, and piston packed with double reverse cup-leather packings; the piston is 4½ inches diameter, and operates freely in the upper part of a gun-metal cylinder 3½ feet in length; attached to the bottom of this cylinder, by a socket in the usual manner, is the round stamp-head of chilled cast-iron, 9 inches diameter. The upper end of the cylinder is bored, to receive the piston, to a depth of 14 inches; the piston-rod plays air-tight through the cylinder cover, which is screwed metal to metal on the cylinder. The working barrel of cylinder is pierced with two sets of small holes, for the ingress and egress of air, discharging the air behind the piston after it has been once used as an elastic cushion. Suppose the head to be set in motion with the crank in a horizontal position, the piston being in the middle, vertically, of the working barrel of cylinder, and midway between the two sets of air-holes referred to. As the crank and attached piston rise, the air is compressed between the piston and cylinder cover, and the cylinder, with stamp-head attached, is forced upwards. When in rapid motion, the elasticity of the compressed air between the piston and cover flings the cylinder, with head, some inches above the range due to the motion of the crank; on the descent of the piston below the bottom set of holes in the

cylinder, the air is compressed in a similar manner, and the cylinder is forced down by the compressed air between the piston and cylinder bottom, until the stamp-head strikes the ore in a coffer-trough; thus, whether the quantity of ore be large or small, the blow is always effective, the only difference in the working of the machine being a shorter or longer vertical play of the cylinder and head.

The committee appointed by the North of England Institute of Mining Engineers to investigate the action of safety cages and hooks have made their report. After a most careful investigation of all the inventions which were brought before them, and they were very numerous, they have arrived at the following conclusion:—"That there are really but two different classes, namely, those which come into operation every time the chain is slackened, and those which do so only when the cage is actually falling or descending at a speed almost equal to that of a falling body. Inventions of the first class are very numerous; the second class has one sole exponent, Calow, and both depend on the action of springs (which are always subject to derangement) to initiate the grip, which intensifies itself by being drawn more and more into gear by friction on the guides. Both systems have their advantages and disadvantages; for even Calow's, although it does not wear so much as the others by being constantly in motion at the top and bottom of the pit, yet is apt to stick in the shaft if by any cause the cage receives a sudden jerk."

In conclusion the committee say:—"It must be admitted that, with every desire to see some efficient apparatus in use at every colliery to prevent the lamentable loss of life that occasionally occurs, your committee have felt an instinctive distrust of the various modes hitherto proposed for doing so, which distrust has not been altogether overcome by the investigation that has been gone into. Up to the present time there seems some element wanting to perfect these machines (some of which are excessively ingenious) and render them really reliable, and it is much to be desired that such an improvement may be arrived at speedily. With this feeling your committee cannot express an opinion as to the necessity for the adoption of any of these provisions for safety, and can only lay before you the facts they have acquired, with such deductions from statistics and observations as have presented themselves, and which it is hoped will materially assist in considering the merits of new inventions."

Papers on the Theory and Practice of Coal Mining. By George Fowler, M.E. W. M. Hutchings. London.—Mr. Fowler has read before the Institution of Civil Engineers, and other societies, papers "On the Relative Safety of different Modes of Working Coal," and on kindred subjects. These papers are now gathered together, and, reconstructed, are presented to the public in a very useful form. Each mode of working coal is carefully

described, and the author's views are given as to the relative values of the several systems. It is not practicable, did we even deem it advisable, to enter into any discussion on these questions. We must refer all of our readers who are interested in the subject of mine ventilation to the book itself, which they will find very full of useful information.

Metallurgy.

It is our duty to record such of the numerous attempts as are made from time to time to improve the make of iron and steel as may appear to possess merit. It is not a new idea to use the alkaline metals for removing deleterious ingredients from iron; but we are not aware that it has hitherto been proposed, as is now done by Girard and Poulain, to force the vapour of potassium or sodium through the molten metal. They propose to saturate the fuel with carbonate of soda, and dry it, or to mix common salt with the fluxing materials. These inventors, however, appear to place most confidence in a process for blowing those vapours mixed with moist air, or moist carbonic oxide, through the melted metal in a Bessemer converter. Pure iron or steel is said to be thus obtainable at pleasure. If experience proves this, we shall soon hear more of this process.

The continually-increasing demand for high-class pig-iron and iron ores, caused by the extension of the Bessemer process, has brought into notice the red hematite and magnetic ores of Norway as a possible source of supply for the Continent. According to a statement published in the 'Berggeist,' a paper representing the metallurgical interests of Westphalia and the Rhine provinces, it has recently been suggested to employ the magnetic ores raised in the neighbourhood of Arendal for the production of Bessemer iron on the spot, the total output of which the mines are capable being estimated at 50,000 tons of 40 per cent. annually, which it is proposed to smelt in two moderate-sized furnaces with coke made on the spot from washed English small coal. Whether such a proposal is likely to be commercially successful may be doubted; but the point is in so far of interest as showing how completely iron making is now governed by the item of cheap fuel; the making of charcoal pig-iron even in a thickly-wooded country like Norway being nearly at an end, for out of fifteen blast-furnaces in the southern part of the country only five are now in blast, the cost of production of pig-iron being nearly 6*l.* per ton, owing to the high price of charcoal. On the system proposed, the cost of No. 1 grey Bessemer iron is computed at 68*s.* 6*d.* per ton, which, could it be realized, would leave a fair margin on the selling price of hematite pig-iron in our north-eastern ports.

The question of the exact nature of the changes involved in the conversion of pig-iron into steel in the Bessemer process, or rather of the composition of the pig-metal employed, is still a matter of great uncertainty. That sulphur, phosphorus, and copper are in no degree removed during the process, and that consequently these impurities must be absent from the metal treated, is proved by all the analytical investigations made in this country as well as in Sweden and Austria. As regards the question of silicon, Professor Jordan, of Paris, has recently pointed out, in a memoir published in the 'Revue Universelle,' the probability that the enormous heat developed in the process is mainly due to the combustion of this element, because the whole of the heat produced by the burning of silicon to silica, of silicate of protoxide of iron in the slag, and the subsequent formation is entirely retained in the metallic bath, while that produced in the combustion of the carbon to carbonic oxide is in great part carried out in the current of flame and heated gases issuing from the mouth of the converter. The exactitude of this view cannot of course be positively demonstrated, because neither the calorific power of silicon nor its specific heat has yet been determined. If, however, we assume with Professor Jordan, which is not improbable, that these factors are the same for silicon as for carbon, it can be shown that in the conversion of a pig-iron containing 4·25 per cent. of carbon and 2 per cent. of silicon that the amount of heat developed by the combustion of the latter element is more than six times as much as that obtained from the former. In proof of this statement it is asserted that the Bessemer process could only be successfully carried out at Terrenoire in France when the metal was run direct from the blast-furnace to the converters, the small proportion of silicon, about 1½ per cent., present being not sufficient to allow it to be cast into pigs and remelted, as is usually done. The dark grey No. 1 Bessemer pig-iron produced in Cumberland and Lancashire contains generally from 2·6 to 2·7 per cent. of silicon. It appears to be probable, however, that when too much silicon is present, or rather when its proportion as compared with that of the carbon is too high, it may not be entirely removed in the blowing.

The separation of sulphur and phosphorus from iron has long been a problem of much interest, especially so since the introduction of the Bessemer process. At the Working Men's International Exhibition at the Agricultural Hall, London, is a display of specimens of iron obtained, by a process invented by Sir Antonio Brady, from some of that dockyard refuse irreverently described as "Seely's pigs," and which has been the subject of discussion both in Parliament and by the press. These pigs were of different qualities, but were all largely contaminated with phosphorus and sulphur, and were supposed to be of little or no value. The presence of phos-

phorus renders iron brittle when it is hot; the presence of sulphur renders it brittle when it is cold. The pigs containing both were worth in the market about 2*l*. 5*s*. a ton. By Sir Antonio's process the sulphur and the phosphorus is said to be extracted at a cost of about 35*s*. a ton, and the residual iron is described as "superb." One of the pieces exhibited is stated to have been beaten cold to the thinness of writing paper at one end, drawn to a point at the other, and then twisted by hand eight turns in an inch at a single heating. Massive bars are said to have been beaten cold until the surfaces on each side of the bend came into perfect contact, and a plate six inches wide and half an inch thick to have been beaten till its edges were in contact, the flat surface remaining horizontal. In neither case was there any trace of a flaw, either at the convexity of the curve, where the metal was stretched, or at the concavity, where it was compressed. Holes in a thick plate are labelled as having been enlarged by driving cones into them, and, in a word, the iron is described as having been knocked about in every possible way. At a very low estimate it is affirmed to be worth 14*l*. a ton, and as there is plenty of the raw material to be had, the profit of the invention seems likely to be great.

A remarkable steel casting was made recently at the works of Messrs. Thomas Firth and Sons, Sheffield, which deserves a record. This casting is to form the shaft of the screw of the Dublin Steam-Packet Company's vessel 'Munster,' and is about 15 feet in length by nearly 4 feet in diameter, and weighs over fifteen tons. This is one of the largest blocks of steel ever cast in this country.

The work of melting commenced about eight o'clock, in no fewer than *five hundred and forty-four* crucibles, each containing 64 lbs.—the total quantity of steel being 34,816 lbs. At half-past twelve the work of casting began, and was rapidly completed, by the joint and perfectly organized action of 300 men. This metallurgical operation was a perfect triumph of mechanical skill.

The enormous difficulty and expense caused by the ever-accumulating mountains of slag produced by iron furnaces worked on the modern scale, often amounting to as much as 60 tons per furnace per day, has led to different proposals for utilizing these unpleasant *ejecta*, and we remember certain glowing descriptions of valuable results to be got by converting the despised slags into materials rivalling the finest porphyries and other ornamental rocks. The less ambitious but more practical plan of using them as paving stones has been for some time past under trial in Brussels, and, according to Kennis, with such success that they are to be employed generally in the repavement of that city. The process employed is simply that of allowing the cinder to run from the furnaces into an excavation sufficiently large to contain the whole daily yield of several furnaces, and the cooling is retarded by covering the surface

with earth when the pit is filled. When cold the mass is found to leave a widely-radiated structure, recalling that of natural volcanic rocks, and the texture is that of a finely crystalline or granular porphyry, having a mean specific gravity of 2·77. The surface is said to wear in such a manner as not to become slippery under traffic, and the cost to be 20 per cent. less than that of ordinary stone paving. It is very much to be desired that experiments of this character should be carried out in the only district in this country where blast-furnace slags are used as a road material to any great extent, *viz.* in Northamptonshire, where, according to the present method, the general character of the roads may be represented by a series of parallel ruts filled with broken glass, owing to the slag used being cooled in small masses, producing a vitreous substance unfitted for road making, but which is used owing to the difficulty of obtaining natural stone for the purpose.

A new process of casting metals has lately been attracting considerable attention. In July a number of gentlemen met at the Lancashire Engineering and Compression Casting Works, at St. Helens Junction, to witness the new process of casting in brass and iron chased and embossed work of the most elaborate description. The process, which was here for the first time exhibited in England, is an American invention, and its utility was shown to consist in this—that any design, whether in high or low relief, chased on metal of any required pattern or shape, whether flat as a door-plate or round as a vase, can be produced by castings from it *ad infinitum*, and each casting will show upon it all the sharpness and beauty of the original chasing. Moulds are made with a preparation of fine clay from the articles to be reproduced. The making of one of these moulds takes a person from five to ten minutes. The moulds have then to stand twenty-four hours exposed to dry air, after which they are baked in a furnace for eight hours. These clay moulds, into which the metal is afterwards poured, are, to all intents and purposes, encaustic tiles. The moulds are placed in a box, and the air is extracted from them so as to form a vacuum, after which the molten metal is forced into them, and in this way, in ten minutes, a casting can be completed. When the casting is taken out, the design, however intricate, is found to be perfectly represented, with the exception of removing a slight surface of clay from it, which can be done in half an hour, and the article is then ready to be sent to the bronzer, instead of having to be kept in the chaser's hands. In this way an enormous amount of cost and labour on ornamental articles in metal is saved.

A new process for refining and desilvering lead has been introduced by Gustave Luce, Son, and Bozan, of Marseilles. The invention consists in the application of steam. For this purpose the crude argentiferous lead is melted down in a vessel heated by a

fire, and provided at its lower end with a spout, closed with a slide, through which, when the lead is melted, it is caused to flow down into a lower vessel or vat, heated only at times directly by a special fire, and at other times by the waste heat from the fire of the upper vessel. When the lower vessel is full, steam is introduced through a central pipe, leading down to near the bottom of the vessel, where it is provided with a cock turned by a rod from above, and with a disc, for the purpose of dividing the steam as it enters. The steam, in passing up through the molten lead, effectually oxidizes all impurities, which then rise in the form of scum to the top of the metal, whence they are removed. The introduction of the steam at the same time produces a violent ebullition of the lead, causing it to crystallize; and when this crystallization has taken place to a sufficient extent the introduction of steam is stopped by closing the cock on the steam-pipe, and the remaining liquid portion of the lead, in which the greater proportion of the silver will be found concentrated, is run off through one or more spouts into troughs turning on pivots for conducting the lead into a series of ingot moulds. During this time a fresh charge of lead, containing a percentage of silver approximating to that of the crystals in the lower vessel, has been melted down in the upper vessel, and is run into the lower vessel as soon as all the liquid portion has been removed therefrom. Steam is then again introduced, effecting a further purification and separation of silver, and this process is continued until, by the repeated crystallization, one part of the lead is rendered comparatively free from silver, to be used as merchant lead, while the lead run off is sufficiently rich in silver for the cupelling process. The duration of each operation for twelve or thirteen tons of argentiferous lead is about from two and a half to three hours.

The Iron and Steel Institute, whose first provincial meeting was held at Middlesbrough last year, has just held (September, 1870) another such meeting at Merthyr Tydfil, the chief seat of the coal, iron, and steel industries of South Wales. The formal business meetings of the Institute extended over two days, and other two days were devoted to the inspection of the iron and steel works at Swansea and Ebbw Vale. Although the Institute has not yet been in existence two years, there are already upwards of 350 members enrolled, a large proportion of whom were present at Merthyr, notwithstanding its great distance from the other principal seats of the iron-trade, and the difficulty attending the means of reaching it. At the meeting just held, the Duke of Devonshire presided, and Mr. Henry Bessemer was elected to the presidentship for the ensuing two years. The Council of the Institute have resolved to discontinue the publication of the 'Transactions of the Institute,' and to issue instead a quarterly journal devoted to the

science and practice of the iron and steel manufacture, both at home and abroad. The foreign editorship of the journal is to be conducted by Mr. David Forbes. Several very interesting and important papers were read and discussed at the Merthyr meeting. We can only find space to indicate the subjects upon which they treated.

I. "The Geological Features of the South Wales Coal-field." By Mr. William Adams, Cardiff. In this paper the extent of the coal supply of South Wales was put down at 36,000,000,000 tons, even after making a very liberal allowance for faults, waste, loss in working, &c.

II. "On Pumping and Winding Machinery at the Castle Pit, Cyfarthfa." By G. C. Pearce, Cyfarthfa Iron-works. This was a short paper describing some recently-erected machinery of a superior character, and which was carefully inspected in operation by the members.

III. "On the Condition of Carbon and Silicon in Iron and Steel." By Mr. Geo. J. Snelus, Associate of the Royal School of Mines. This was the longest and most elaborate paper read at the meeting. In it the author showed that he had struck out a new path, a method, or rather methods, of mechanically separating the carbon and silicon contained in iron and steel, which will doubtless prove to be a valuable supplement to the ordinary methods of chemical research.

IV. "On a New Form of Pyrometer." By Mr. C. W. Siemens, C.E., F.R.S. The author described several kinds of pyrometers, and then described and exhibited one constructed upon a plan involved in the principle that the pure metals have the property of offering an increasing resistance to the passage of an electrical current with increase of temperature.

V. "On the Efficiency and Durability of Plain Cylindrical Steam-Boilers." By Mr. Jeremiah Head, Middlesbrough. The author of this paper gave an account of a new method of suspending or supporting plain cylindrical boilers so as to prevent explosions. Out of nearly 18,000 boilers on the books of the boiler insurance companies, 22·7 per cent. are of this sort, thus showing that they are much in request. A method of ensuring their safety is therefore a thing much to be desired.

Other two papers were set down for reading, but there was no time left for them. One of them was by Mr. F. Kohn, C.E., and the subject was, "On the Production of Alloys of Iron and Manganese, and on their Application to the Manufacture of Steel."

11. PHYSICS.

Light.—A new substance possessing fluorescent properties in a very high degree has been prepared by Professor A. H. Church from the *Cyclopia vogellii*, one of the plants used by the African Boers for tea. It possesses acid properties, and the discoverer calls it cyclopic acid. Its action on light is best seen when a crystal or two of the new body is dropped into a solution of caustic soda and viewed in sunlight. An intense greenish-yellow fluorescence is perceived at first, but disappears in the course of some hours.

A new artificial light which has recently been successfully experimented with, called the Philipp carbo-oxygen lamp, and its recent trial at Cologne, was such as to win approval on every hand. The light is generated by the combustion of a liquid chemical compound in a current of oxygen, arrangements for the purpose being constructed in a suitable lamp. The gas is derived from the atmosphere either by chemical or mechanical means; the chemical methods being to absorb the oxygen of the air with chloride of copper (Mallett's method), or with manganate of potash (Tessie du Mothay's method), while the mechanical mode is that of utilizing the different degrees of solubility of nitrogen and oxygen in water or other liquids. By compressing atmospheric air into receivers filled with water, a portion of the nitrogen is taken up by the water, while the oxygen remains insoluble in the water; the air thus containing a goodly proportion of oxygen is forced into a second reservoir of water, where a further amount of nitrogen is absorbed, and after the operation has been repeated seven or eight times, an atmosphere is obtained containing 97 per cent. of oxygen. The nitrogen which has been separated is made use of in a well-constructed apparatus as an auxiliary to the motive force. Experiments have established the fact that a flame fed with air containing 53 per cent. of oxygen yields a light equal in brilliancy to that obtained with pure oxygen, and with diluted oxygen of this kind the Philipp flame has a brilliancy of 90 to 100 candles, or ten times that of an ordinary gas jet. The light is of a bluish-white, resembling very much that of electricity or burning magnesium. The liquid employed consists of liquid hydrocarbons very rich in carbon; it costs but little, burns economically, and can be employed only in this particular direction. The flame is made to assume the form of a star, and any heating of the wick-holder thereby prevented; if of the size and power above mentioned, the quantity of gas consumed is 5½ cubic feet per hour. As to the lamp, no special attention is necessary beyond that of filling it with liquid, as the wick is of a very durable nature, and needs no trimming.

An optically-neutral sugar has been prepared by E. J. Maumené. He mixes equal parts of pure sugar-candy and neutral nitrate of silver, both previously dissolved in water, and evaporates the mixture upon a water-bath. He states that neither at 100°, nor even at 140°, any decomposition ensues or any reduction of silver takes place, provided the sugar be free from inverted sugar. The sugar, rendered syrupy by the process described, is optically neutral. The silver-salt is separated from the sugar by means of pure chloride of calcium, and the nitrate of lime is separated from the sugar by the addition of alcohol and placing this mixture under a bell-jar along with quick-lime. In this manner, by slow concentration, two layers of different specific gravity are formed: the upper being an alcoholic solution of nitrate of lime, the lower a viscous saccharine liquid. The former is poured off, and, by a slight washing with cold distilled water, the thick sugar solution is freed from any adhering nitrate of lime. The sugar obtained does not crystallize.

In a lengthy paper on the optical properties of benzyl, and of some substances belonging to the camphor groups, in the crystalline state and in solution, M. des Cloizeaux describes a series of experiments, the chief results of which are that benzyl and periodate of soda possess, when in the solid crystalline state, strongly-marked rotatory powers, and are devoid thereof in the state of solution. Quartz, chlorate, and bromate of soda act the same. Sulphate of strychnia possesses rotatory powers in crystals as well as in solution, while ordinary camphor, patchouli camphor, camphor of oil of mint, Borneo camphor, tere camphor, and monchlorhydrate of turpentine possess rotatory power when in solution, but not in the crystalline state.

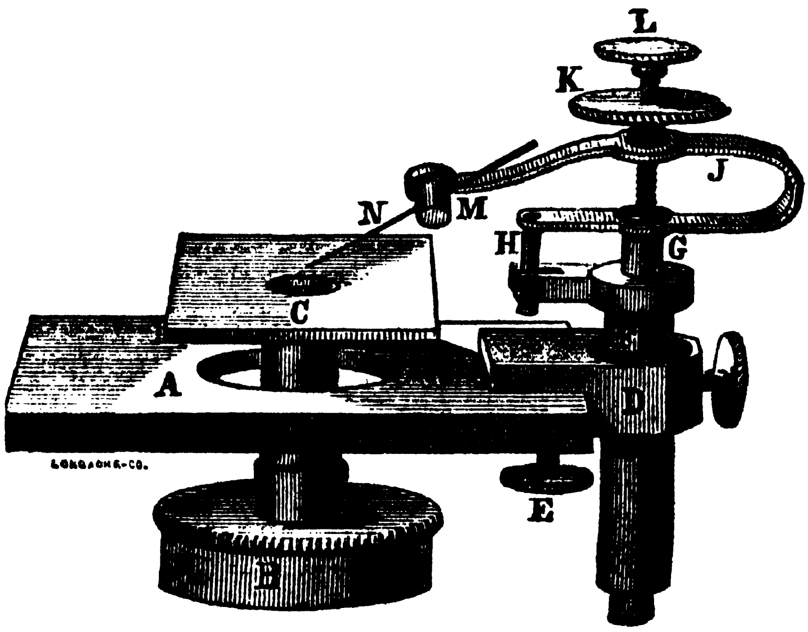
O. Loew has found that when aqueous sulphurous acid is exposed in sealed tubes to the action of sunlight, it is gradually reduced to sulphur, but the oxygen is not liberated, another part of the acid having been oxidized by it to sulphuric acid.

According to J. Girard, who has made several voyages on the Mediterranean Sea, its peculiar colour, ranging from pale blue through all shades of that colour to black (*viz.* when seen from a ship's deck), is entirely due to the mode of reflexion of the sun's rays according to the lower or higher position of that luminary above the horizon, so that at mornings and evenings, when the rays fall more obliquely and pass therefore through a larger bulk of water the colour is deepest, provided it be at such distances from the shore that the depth of the sea is sufficiently great.

At one of the recent meetings of the Franklin Institute, Professor Morton exhibited in the lantern some pictures on gelatine prepared in a manner devised by Mr. Holman. For this purpose

a sheet of gelatine, such as is used for tracing by engravers, was securely fixed over an engraving, and with a sharp steel point (made by grinding down the end of a small round file), the lines of the original traced pretty deeply on the transparent substance. Lead-pencil or crayon dust was then lightly rubbed in with the finger, and the picture was at once ready for use. A number of such drawings could be easily carried between the leaves of a book, each in succession being held in a frame or cell made of two plates of glass separated by a frame of thin card or three edges, and united by paper or muslin pasted around the same edges. The effect of these drawings in the lantern was excellent, and their ease of production very great.

A most valuable adjunct to the microscope has been made by Mr. J. Zentmayer. It is a mechanical finger, which in the study of diatoms forms a substitute for the clumsy fingers of the human hand, to do the delicate work of picking up rare and valuable diatoms detected by the microscope, and to transfer them to a slide for preservation. The instrument may be readily understood on reference to the accompanying cut.



A is the top plate of the mechanical stage; the circular plate is omitted. The cap B is fitted to the lower body below the stage, into which cap the new sub-stage C is fastened by a narrow tube, wide enough to admit illumination from the mirror. As the lower body is movable up and down by a rack, another movement is gained which is necessary to accomplish the result. The difference of the size of the aperture of the stage and the diameter of the tube which connects the sub-stage with the cap A is equal to the movement of the mechanical stage, and this is found more than sufficient. D is the clamp by which the finger is attached to the stage by means of the screw E. A steel cylinder, G, is nicely fitted into the top and bottom of the tube F, leaving room inside for a light spring to press the steel cylinder upwards. To prevent turning, the spring J is provided at H with a steel pin, accurately fitted into the fork at the top of the tube F. By turning the nut K the spring J is elevated and depressed, giving nice adjustment to the needle N in case the finger is to be attached to a microscope not having rack movement to the cap B, to bring the end of the hair and the object in close approximation. The end of the spring J forms a little ring, with

a screw cut inside into which a cork M is screwed to receive a needle N, to which a hair is fastened by wrapping gum paper around. Turning the cork facilitates the adjustment of the hair to the proper inclination. A slight pressure on the button L brings down the hair, and the spring inside of F instantly lifts it again when the pressure is removed. The tube F turns in the clamp D in order to adjust the hair and cork more conveniently, and when brought back again it is tightened by a set screw. Complicated as it may appear, only one movement is added to the microscope stand by this instrument, the one, namely, which gives the vertical motion. When the apparatus is to be used, the material to select from is placed on the sub-stage C and focussed, then the point of the hair is approximately brought over the selected object by means of the stage movements and turning of D; this brings the hair nearly in focus too, because it is almost in the same plane with the object. Next adjust the hair precisely over the selected shell, press down the button L, and the shell will adhere to the hair. Now remove the slide with the material and substitute a glass slide moistened by breathing on it, and having brought it in proper position briskly dip down the button L again and the shell will be deposited on the glass slide. If the mechanical stage has a graduated indicator, the finger may be moved along regularly and shells may be placed at equal distances in lines. After the cover glass is carefully placed over it, Canada balsam may be run in by capillary attraction without disturbing the position of the shells.

HEAT.—Dr. J. D. Boeke, Teacher of Chemistry at the Hoogere, Burgerschool at Alkmaar, opposes the statement of Mr. Loew that ozone is formed by rapid combustion. On repeating Mr. Loew's experiment with this slight modification, that a stream of *oxygen* instead of *air* was blown through the luminous flame of a Bunsen's burner into the mouth of a glass balloon, he really found that the air in the balloon had assumed a peculiar odour, and the property of colouring blue a mixture of starch paste and of potassium. But it appears that both changes are the result of the formation of a compound of *oxygen and nitrogen* (probably dinitric trioxide or nitric dioxide), *not* from the formation of *ozone*, as Mr. Loew asserts. So when Mr. Loew declares that he was able to "identify the formation of *ozone* by its intense odour and the common tests," he was somewhat rash in this conclusion. Still Mr. Loew's experiment is a very interesting and easy one, and will soon take its due place in the series of lecture-experiments intended to elucidate the complex phenomena of combustion.

H. Sainte Claire-Deville relates at great length a series of experiments which may be summarized as follows:—Perfectly pure iron kept at temperatures varying from 150°–1600°, is treated with

vapour of water of a known tension and temperature. Under these conditions results are obtained which prove that the decomposition of vapour of water by iron while red-hot is rigorously subject to all the laws which govern the tension of saturated vapours.

M. E. Cappel has published a lengthy paper on the influence of the temperature on the sensitiveness and delicacy of spectrum reactions. The main result is, that the temperature most suitable for the spectrum analysis of the alkalies is that of the oxyhydrogen flame, and for the rest of the metals the heat of the electric spark. The higher the temperature the more distinct the reactions.

In some observations on the batswing-burner flame, Dr. A. Baudrimont states that the flame consists of two distinct portions, one of which (the interior) has a comparatively low temperature while it is surrounded by a luminous envelope, the temperature of which exceeds that of molten platinum. Indeed the author found that a platinum wire $\frac{1}{10}$th mm. thick, when properly placed in this flame, fused immediately.

General Morin has experimented at the Conservatoire des Arts et Métiers on some fire-clay stoves; the results are said to be highly satisfactory. The useful effect of heat given off by the fuel amounts to 93 per cent. The air in the rooms where these stoves were placed was not at all vitiated so as to incommode those present, notwithstanding the interior of the stoves became thoroughly red-hot. The author says that, taking all in all, these stoves, when suitably connected with flues, will afford a cheap and in every respect wholesome mode of heating apartments.

A new material for the manufacture of crucibles is described by M. J. Desnoyers. The substance known as gaize, or *pierre morte*, is a mineral largely met with in the departments of the Ardennes, where it forms a deposit of some 100 mètres thickness. Its specific gravity is 1·48. It is on being dug up quite soft, so that it can be cut with a knife, but becomes hard on drying and very hard when exposed to red-heat, whereby its specific gravity is reduced to 1·44. This material is essentially a substance capable of withstanding high temperatures; and the author exhibits crucibles made from the gaize which have been used successfully for melting iron. Dr. La Salvelat, the celebrated chemist of the Imperial Porcelain Works at Sèvres, states that layers of similar material exist in the central parts of France, and that these minerals are of great value for the construction of blast and other furnaces.

By the term "rochage," H. Caron understands a peculiar production of sparks, best seen when molten cast-iron is run off from the blast furnace into moulds. In a lengthy paper the author describes a series of experiments undertaken with the view to prove that since steel and cast-iron, when molten in an atmosphere of

hydrogen or oxide of carbon, never emit sparks, the production of the latter cannot be due to an evolution of reducing gas absorbed during the fusion, but is due, according to the author, to the formation of oxide of iron at the moment the molten metal comes in contact with air. This curious phenomenon is well known to those engaged at blast furnaces. The sparks are known by the workmen as "jumpers," and their presence is usually held to indicate an approximation to white iron. These sparks are absent during the running of grey iron from the furnace, and only begin to make their appearance when the iron is about No. 4, the usual degree of greyness preferred in South Staffordshire for puddling. The sparks are best observed during the running of white iron from the furnace, especially if the molten metal is not very fluid, at which times a vast number are produced, particularly in the channel; and sometimes after the pigs have "set," little jets of sparks are continuously discharged for many minutes, which discharge is accompanied by a hissing sound. M. Caron's view may probably be correct, but a correspondent of the 'Chemical News,' who signs his name T. B., says that he is inclined to attribute the production of these sparks to the combustion of carbon and not of iron, as there is an entire absence of the peculiar scintillations displayed by burning iron.

A very striking mode of demonstration in the lecture-room that burning bodies increase in weight has been contrived by H. Kolbe. A glass rod is fastened in a horizontal position to one arm of a balance. Upon this is fastened a glass cylinder in which a candle is burnt, connected with which, by a glass tube, there is a V-tube for condensing the vapour, a flask filled with lime-water for carbonic anhydride, and two more V-tubes containing soda-lime. The last are connected by an india-rubber tube with a Bunsen's pump, by which a steady current of air is drawn through the apparatus. The beam is first counterpoised; as the candle burns away the arm of the balance to which it is attached sinks down until its progress is arrested by the table.

Mr. W. T. Suffolk, the well-known microscopist, has experimented during a pedestrian tour on the most advantageous methods of boiling water, and has come to the conclusion that the very best arrangement is an "Etna" of French construction made of very thin copper, electro-plated, and weighing, with a store of 6 oz. of spirit, 1½ lb. The time occupied in boiling half a pint of water is from seven to ten minutes, and the consumption of spirit about two fluid drachms. The apparatus requires a perfectly calm atmosphere for its proper action; this may be secured by building a small *cromlech* of flat stones, which are always at hand in hilly countries, and with the help of a large handkerchief as a further protection against the wind, no difficulty will be found in securing

efficient performance; other contrivances will suggest themselves where stones are not procurable. Although it would seem that alcohol is consumed to a disadvantage without a wick, yet practically the "Etna" boils water with a smaller consumption of spirit than any contrivance yet tried, a good argand lamp requiring at least half an ounce to do the same work as the Etna. The Russian blast lamp is still more wasteful, consuming nearly 2 ounces. The superior economy of the Etna is attributed to the low temperature of the wickless flame and the manner in which the boiler is wrapped in the fire, no more heat being supplied than can be taken up by so bad a conductor as water. The defect of all lamps giving an intense flame being that heat is wasted by being supplied too quickly, so that the apparently feeble fire in the gutter of the Etna is more efficient than the heat of powerful lamps, as well as more economical; the latter quality is very important to the pedestrian, to whom every ounce of weight is a consideration.

P. Lewald, referring to the phenomenon first observed by Dr. Fritsche, says it is not at all a correct statement that the blocks of tin exposed to a cold of $-35°$ should alter their state of aggregation from that cause; the real cause is that the blocks of tin usually of 250 cubic inches capacity are cast in iron moulds, and as a consequence thereof the tin contracts unequally, and so as to leave in the inside of the blocks cavities often so large as to occupy 40 cubic inches. These hollows are lined by a crystallized metal at a high degree of tension. The tin at St. Petersburgh was laying heaped block upon block, and the effect of the cold was simply a remote cause to what took place, the weight of the blocks of metal placed on each other being such as to produce necessarily a pressure too great to be borne by the undermost blocks. The author says, if tin is molten and allowed to cool, so as to shrink uniformly, no cold, even of $-40°$ or less, will have the effect observed in the locality alluded to.

L. Cailletet has studied the variation of compression of air and hydrogen between 1 and 800 atmospheres. Up to 80 atmospheres' pressure, air is more compressed than it should be if it followed the law of Mariotte; and at 680 atmospheres' pressure it only occupies two-thirds of the space which it ought to do theoretically. The method by which the author is enabled to measure the volumes occupied by a gas in an opaque apparatus is very simple. The glass tube is enclosed in an iron one; the former, containing the gas, is lightly gilt. The mercury which serves for the transmission of pressure, whitens the gold, leaving a well-defined mark on it after the pressure ceases.

Electricity.—In a letter to M. Dumas, Professor de la Rive states that he has just finished a series of experiments on the mag-

netic rotatory power of liquids, the results of which will be shortly published. The first portion of this work is devoted to the description of the apparatus and processes of experimentation; the second part contains the results of the determination of the magnetic rotatory power of some liquids. As a curious anomaly the author mentions that taking water as unit, the coefficient of the magnetic rotatory power of monohydrated sulphuric acid is 0·750, and that coefficient is, for liquid anhydrous sulphurous acid, equal to 1·240 at a temperature of 12°. The third part of this work is devoted to the study of the influence of the temperature on the magnetic rotatory power. In the fourth part, the author gives the results of his investigations of the magnetic rotatory power of a mixture of two liquids as compared with that each of these liquids possesses separately. The fifth part contains the results obtained by experimenting with two isomeric liquids.

In some experimental researches on the length of duration of the electric spark, MM. Lucas and Cazin employ two transparent discs placed upon the same axis. One of these discs is a fixture, while a more or less rapid rotatory motion can be imparted to the other. Upon both discs are painted the same number of opaque stripes in the direction of the radius. When, therefore, an electric spark is observed through these discs, a certain amount of speed having been imparted to the movable one (the apparatus being placed in a darkened room), it is clear that by the light emitted by the spark a certain number of coincidences of the movable and fixed stripes may be observed, and these coincidences may serve to calculate the period of duration of the spark.

Dr. Demayes describes at length an apparatus constructed by him, which appears to be an improvement on Siemens' electromagnetic apparatus; while making from 250 to 280 revolutions a minute, the lifting power of the magnet is 70 kilos., and under similar conditions a platinum wire, 0·8 mm. thick and 20 centim. long was rendered red-hot, and iron wire of the same thickness fused; the machine produces per second of time half a cubic centimètre of gas by the decomposition of water.

In a recent instalment of his researches on electro-capillary action, which have occupied M. Becquerel for a series of years, he announces the artificial formation of the oxychloride of copper in crystalline state, and exactly similar to that found in the copper mines of Peru and Chili, and known as atacamite. This formation has taken no less than fifteen years.

Mr. E. W. Blake, jun., has described a method of producing by the electric spark figures similar to those of Lichtenberg. The method consists in throwing the discharge upon the surface of a fusible non-conducting body. If the body be near its fusing-point

the figure appears at once; if cold, a latent image exists, which may be developed by heat. The non-conducting surface is prepared by coating a plate of metal with an even film of pitch. Pieces of sheet tin, 3 inches square, coated with films of pitch of a thickness varying between 0·01 and 0·02 inch were used; the pitch was the ordinary article of commerce freed from sand, &c., by being melted and strained through a muslin bag. The author gives cuts of the figures as produced by frictional electricity and the induction coil.

Metallic iron, as obtained by the electric current, has been examined by C. Collas. He employs a weak solution of chloride of iron, which is decomposed by the aid of a Bunsen battery; perfectly pure iron is thus obtained, which is very friable, highly oxidizable, especially when moisture is present. When this iron in the state of fine powder is poured in a bottle when the atmosphere is very moist, the iron is instantaneously oxidized, water decomposed, and the evolution of hydrogen causes the bursting of the bottle.

A new method of copper extraction and its separation from other metals is published by Mr. J. Elkington. The principle consists in applying electricity for dissolving the copper contained in the crude metal obtained by the usual smelting methods, and for depositing that metal galvanically upon plates of copper, causing the other foreign metals to fall to the bottom of the vessels in which the operations take place; copper containing very small quantities of silver may be advantageously treated thus for the recovery of the last-named metal.

An improvement in galvanic batteries has been devised by Mr. W. Poole Levison, of Cambridge, Mass. While making use of a small bichromate of potash battery he discovered that the addition of nitric acid to the mixture of potassic bichromate and sulphuric acid contained in its porous cups, conferred upon it the virtue of *steadiness* without involving the evolution of annoying fumes. For over two months during last summer the author had in almost constant action a combination of twenty-three large Bunsen cells charged with dilute sulphuric acid and the triple mixture mentioned, and "set up" openly upon the floor of the room. Not only did he work about it with perfect comfort, but left choice brass instruments in its immediate neighbourhood with impunity. Its energy never fluctuated, but after remaining for some time steady declined, precisely as if the electro-negative plates were bathed in nitric acid only. To a cooled mixture of potassic bichromate solution and sulphuric acid (perhaps preferably in atomic proportions) add *nitric* acid. The proportion of nitric acid may be greatly varied, as its office is merely to transfer oxygen.

A research on the best methods of tinning of iron without the

aid of heat has been carried out by J. B. A. Daubié. The chief point of interest is that the tinning of iron in the cold cannot succeed at all, unless the bath used for that purpose contains in solution or suspended an organic substance like starch or glucose, although no precise scientific explanation of this indispensable condition has been hitherto given. The author employs the following bath: To 100 litres of water are added 3 kilos. of rye meal; this mixture is boiled for half an hour, and next filtered through cloth. To the clear but thickish liquid are added 106 kilos. of pyro-phosphate of soda, 17 kilos. of protochloride of tin, 100 to 120 grammes of sulphuric acid; this liquid is placed in well-made wooden troughs, and serves more especially for the tinning of iron and steel wire for the use of carding-machines. When instead of the two salts of tin just named cyanide of silver and cyanide of potassium are taken, the iron is perfectly silvered.

12. ZOOLOGY AND MORPHOLOGY.

The Zoological Position of the Brachiopoda.—Leuckart, Haeckel, and Gegenbauer do not include the Polyzoa among the Mollusca, as is done by Huxley, but class them as also the Tunicata among the great heterogeneous group of Vermes. Mr. Morse, an American naturalist, who has devoted much study to the Molluscoida, proposes to turn over the Brachiopoda into the same position. In doing so he unconsciously meets an argument advanced in favour of the retention of the Polyzoa among Mollusca by Professor Rolleston, *viz.* that they present close affinities to the Brachiopoda, especially to the larval Brachiopod described by Fritz Müller. Mr. Morse has by perseverance obtained the great advantage of studying living specimens of *Lingula*, a species of which he obtained in quantity on the North Carolina coast. He compares the setæ which fringe the mouth of *Lingula* to those of Annelids (in this he is probably misled), the lophophor with its cirrhi to the cephalic appendages of tubicolous worms, the oviducts with their trumpet-shaped openings to the funnel-like oviducts of many worms; the embryo of *Thecidium*, with its four segments and eye-spots, is adduced, as also the embryo of *Discina*, which, according to Fritz Müller, has projecting bristles like the temporary bristles of some Annelid-larvæ. Mr. Morse says it is a startling discovery that the vascular fluid of *Lingula* is red, and seems to think that this colour gives this Brachiopod some affinity to worms. It is, however, not at all surprising, though *Lingula* is an interesting addition to the category of invertebrata with red blood, including as it does already the molluscs *Planorbis* and *Arca*. Probably

the coloration is due to Hæmoglobin as in the cases of Molluscs, Insects, Crustacea, and Vermes with red blood, investigated by Mr. Ray Lankester. Mr. Morse's proposition to classify Brachiopoda with Vermes deserves full consideration, but we shall look for some solid reasons in the memoir which he promises on the subject.

New Sponges.—Sponges continue to occupy a great deal the attention of naturalists. Dr. Perceval Wright, Mr. Carter, Mr. Charles Stewart, and others, have lately described new genera and species. Mr. W. S. Kent, of the British Museum, who two months since made an expedition to the coasts of Portugal in the yacht of Mr. Marshall Hall, has described three new species (two belonging to new genera) of that very important and interesting group, the silicious sponges or Vitrea of Professor Wyville Thomson. The Vitrea are represented by the notorious *Hyalonema*, or glass-rope sponge; by *Euplectella*, the beautiful lace-sponge; and by Professor Thomson's new genus, *Holtenia*. Mr. Kent would recognize Dr. J. E. Gray's division of the Corallispongia in preference to that of Vitrea proposed by Professor Wyville Thomson. In describing a new species allied to that author's *Holtenia Carpenteri*, he points out that the genus *Holtenia* must give place to *Pheronema*, previously proposed by that most distinguished of American naturalists, Dr. Leidy, of Philadelphia. There appears to be no doubt that the sponge described under this name by Dr. Leidy is generically identical with Wyville Thomson's subsequently described *Holtenia*. Mr. Kent's new species is called *Pheronema Grayi*, and was obtained by him in the deep sea off the coast of Portugal. Two other interesting vitreous sponges were also detected, and have been fully described by Mr. Kent. The Royal Society assisted Mr. Kent in the outlay necessary for dredging apparatus, &c., and these new sponges are among the first of the fruits of his voyage which he has made known. The Society has done well to entrust some of its funds to this promising naturalist; and zoological science is much indebted to Mr. Marshall Hall for using his yacht for its advancement.

Bathybius and the Coccoliths.—The organism which Professor Huxley described two years ago as being so widely spread in the ooze of the ocean bottom, consisting of a simple ramified network of protoplasm, has been recognized and fully established by no less an authority than Professor Haeckel, of Jena. Professor Haeckel gives figures of the protoplasmic network, and then discusses the propriety of associating with this organism the Coccoliths and Coccospheres, as Huxley has done. He does not arrive at definite conclusions on this point; but re-figures all the various forms of Coccoliths, Cyatholiths, and Discoliths described by Huxley. Haeckel would at present definitely establish Bathybius on the

protoplasmic network, and leave the exact origin of the Coccoliths doubtful. A very remarkable observation which he has made necessitates this; for he has discovered a new genus of oceanic Radiolarians, in the centre of each specimen of which he finds a mass of concretions which really cannot be distinguished from a Coccosphere. In fact, we may say that Coccospheres are found inside these new Radiolarians. At present there is nothing to show how they got there: whether they are secretions of the Radiolarian, or whether they have been taken in by it. Meanwhile the Coccoliths have been observed in other oceanic accumulations besides the Atlantic mud and the Chalk.

Miscellaneous.

Mr. Darwin and the French Academy.—At the outbreak of the present war between Germany and France, the claims of our great naturalist, to be elected a corresponding member of the French Academy, were under discussion in that body. There is nothing which has so fully illustrated the difference between the scientific attitude of France—or rather let us say Imperial France—and Germany, as the manner in which the views of Mr. Darwin have been treated in these two countries. In Germany their almost universal adoption has been the signal for the most active and valuable investigations "fur Darwin;" and the brilliant researches of Fritz Müller, Haeckel, Kowalewsky, and others have proceeded directly from this as a cause. Imperial France on the other hand has, with a rare exception here and there, treated Mr. Darwin with scorn and even insult. M. Flourens, the late perpetual secretary of the French Academy, made a most unseemly attack upon Mr. Darwin some years since, which Professor Huxley showed up for the amusement of English readers in an article in the 'Natural History Review,' which is reprinted in his volume of 'Lay Sermons.' In the recent discussion on Mr. Darwin's claims, MM. Milne-Edwards and De Quatrefages did justice to his merits as an observer, though they do not accept evolution; but Brongniart, Robin, and Emile Blanchard, appear to have expressed a very low opinion of him: he was called 'amateur,' an 'inaccurate dreamer;' and Eli de Beaumont, whose theory of mountain chains has been so completely crushed by Lyell, said that Darwinism "is all fizz"—"*c'est la science moussée.*" And yet it is a fact that Cuvier and Lamarck were Frenchmen.

A New Manual of Zoology.—Dr. H. Alleyne Nicholson, of Edinburgh, lecturer on zoology in one of the medical schools, has, with excellent intentions, produced a manual of zoology. He has not done rightly, for the book is almost entirely an abridgment of Huxley's lectures published in 1856 in the 'Medical Times and

Gazette,' of Greene's 'Manuals of the Cœlenterata and Protozoa' published eleven years since, and of Woodward's 'Mollusca' published fourteen years since. The only additions appear to relate to the geological range of the various groups of animals. No attempt is made to give any of the later results of investigation, nor to seek information from original memoirs. The writer gives his statements at third-hand, and with the exception of some rough diagrams, his figures have appeared in many a manual of zoology published during the last twenty years.

Chloral, the New Opiate.—It is little more than a year since Liebreich suggested the use of the hydrate of chloral as an anodyne, and a few grains of it were obtained at the Exeter meeting of the British Association, through the Pharmaceutical Association, for experiment. Within six months of that time, such is the rapidity with which the medical profession avails itself of any new and valuable discovery, chloral was in daily use in nearly every London and provincial hospital. However much we may complain of backwardness in England in some scientific matters, we cannot but express admiration at the remarkable activity of our medical men. It has been urged upon the bodies who are sending relief to the wounded soldiers in France, to forward chloral and chloroform. Any individual who should go the round of the hospitals, or even on the battle-fields themselves, and administer chloral to those suffering from the pain of wounds, would be able to spare an immense amount of agony, and save many lives. This is one of the adjuncts of war which science offers as a set-off to her *mitrailleurs*. Chloral has also lately been used with much success in some cases by Dr. Robert Caton, in making various physiological experiments in place of curare or chloroform. His methods of studying the tissues of living animals under the microscope, are published by him in the last number of the 'Quarterly Journal of Microscopical Science.' We hear also that Dr. Sanderson, F.R.S., and Professor Stricker, of Vienna, who is now on a visit to this country, have succeeded by the use of chloral, and by proper precautions for maintaining temperature, in studying the living circulation of small mammalia, so as to extend to the mammalia the inquiries commenced by Waller, lately renewed by Cohnheim, as to the emigration of blood-corpuscles from the blood-vessels in inflammation. This is most important as bearing on human pathology and physiology, for hitherto such observations had been confined to the cold-blooded vertebrata—almost entirely, in fact, to fish and frogs, or toads.

Morphology.

Homogeny and Homoplasy.—In the July number of the 'Annals,' Mr. Ray Lankester proposes to use these terms to signify certain relations of parts in organisms which have hitherto been confused under the one head of homology. Homogeny is applied to such structures as owe their identity in arrangement and relation to inheritance from a common ancestor; parts which are thus rendered similar in two organisms are said to be homogenous one with the other. Many structures present, however, a very close similarity in their relations to surrounding parts in two organisms without being so inherited; the similarity being due merely to a community of external conditions in the two cases, necessitating similar corresponding internal arrangements. These agreements are said to be due to "homoplasy," and are called homoplastic one with another. The fore-limbs of all vertebrata are thus broadly homogenous, that is, are inherited from a common ancestor. But the four cavities of the heart of the mammal and of the bird are not homogenous each with each. The hearts as a whole are so, but since the common ancestor of birds and mammals had in all probability a heart with three cavities, the four cavities cannot be due to inheritance in the two cases. They are homoplasts; they are due to similar exigencies in the mammalian and ornithosaurian stock after their divergence from a common stock. Various instances of homogenetic and homoplastic agreement are distinguished in Mr. Lankester's paper, and it is pointed out that what are called serial homologies belong to the category of homoplasts; thus, the fore and hind limb of vertebrata agree in many of their details of structure on account of the mechanical arrangements required in fore and hind limb being to a very great extent identical. In a subsequent number of the same periodical, Mr. St. George Mivart, F.R.S., writing on the use of the term homology, accepts the terms homogeny and homoplasy, though he would retain Professor Owen's word homology, in a wide sense, distinguishing homogenetic homologies and homoplastic homologies. He also proposes to distinguish "ancestral homogeny" and "developmental homogeny." But it appears that "ancestral homogeny" is all that the term homogeny was defined to include. What Mr. Mivart calls "developmental homogeny," when it is not accompanied by ancestral homogeny, falls simply under the category of homoplasy. The subject is a little abstruse, but is of importance, since the doctrine of homology as propounded by Professor Owen has sunk very deeply into the mind of British anatomists; and now that so many have accepted the doctrine of evolution, and the doctrine of creation by types is no longer in favour, it becomes necessary to remodel our terminology in accordance with new ideas.

Quarterly List of Publications received for Review.

1. The Origin of Civilization and the Primitive Condition of Man. Mental and Social Condition of Savages. By Sir John Lubbock, M.P., F.R.S. *Longmans, Green, & Co.*
2. On Microscopical Manipulation. Being the Subject-matter of a Course of Lectures delivered before the Quekett Microscopical Club. *With* 49 *Engravings and* 7 *Lithographs.* By W. T. Suffolk, F.R.M.S. *Henry Gillman.*
3. Heat as a Mode of Motion. By John Tyndall, F.R.S. Fourth Edition. *Longmans, Green, & Co.*
4. Class-Book of Inorganic Chemistry. By D. Morris, B.A. *Phillip & Son.*
5. Chemical History of the Six Days of Creation. *New York: The American News Company.*
6. Papers on the Theory and Practice of Coal-mining. By George Fowler, Mining Engineer. *Wm. Hutchings.*
7. Notes of a Course of Seven Lectures on Electrical Phenomena and Theories, delivered at the Royal Institution of Great Britain. By John Tyndall, LL.D., F.R.S. *Longmans, Green, & Co.*
8. Annual Report of the Smithsonian Institution. *Washington: Government Printing Office.*

PAMPHLETS AND PERIODICALS.

Mineral Statistics of Victoria. *Melbourne.*

Smithsonian Contributions to Knowledge:—

The Transatlantic Longitude as Determined by the Coast Survey Expedition of 1866. By B. A. Gould.

The Indians of Cape Flattery. By James G. Swan.

The Gleddon Mummy Case. By Charles Pickering, M.D.

The Orbit and Phenomena of a Meteoric Fire-ball. By James H. Coffin, LL.D. *Washington: Smithsonian Institution.*

Index to his Observations on the Genus Unio. By Isaac Lea, LL.D. *Philadelphia: T. K. Collins.*

On the Size of Red Corpuscles of the Blood of Moschus, &c. By G. Gulliver, F.R.S.

First Report of the River Pollution Commissioners. (Blue Book.)

Narrative of a Journey to Musardu. By Benjamin Anderson. *New York: S. W. Green.*

Remarks on Prof. Owen's Monograph on Dimorphedon. By Harry G. Seeley, F.G.S. *Taylor & Francis.*

On the Artificial Formation of Organic Compounds. By J. Campbell Brown, D.Sc. Lond.

On Ailanthus Excelsa; a new Indian Remedy. By Mr. Narayan Daji. *Bombay: Asiatic Press.*

A System of Botanical Analysis applied to the Diagnosis of Natural Orders. By W. H. Griffiths, Ph.D. *Wyman & Sons.*

A Sketch of a Philosophy. Part III.: The Chemistry of Natural Substances. By John G. Macvicar, LL.D., D.D. *Williams & Norgate.*

A Lecture on Malt Liquor. By Joseph Livesey.

Public School Reforms. By M. A. B.

Biology *versus* Theology. By Julian.

Statement of a recently-claimed Discovery in Natural Science. By Research. *Melbourne.*

Railway across the Himalaya, projected by R. Stirling, Esq., F.R.S.

Contributions to the Mineralogy of Victoria. By George H. F. Ulrich, F.G.S. *Melbourne: John Ferres.*

Report of the Examiner of Coal-fields in New South Wales. In the 'Newcastle Pilot' (Australia).

Metropolitan Board of Works. Report on Steam Road-Rolling. By F. A. Paget, C.E.

Notes on Books. *Longmans.*

On the Cause of the Motion of Glaciers. By James Croll.

On the Scientific Use of the Imagination. By John Tyndall, LL.D., F.R.S. *Longmans.*

The Technologist. *New York: The Industrial Publication Company.*

The Canadian Naturalist. *Montreal: Dawson Brothers.*

The Food Journal. *London: Johnson, 3, Castle Court, Holborn.*

The American Naturalist. *Salem: Peabody Academy of Science.*

The Geological Magazine. *Trübner & Co.*

Scientific Opinion.

The American Chemist. *New York: Baldwin & Co.*

The English Mechanic.

The Westminster Review.

Revue Bibliographique Universelle.

Fraser's Magazine.

The Popular Science Review.

PROCEEDINGS OF LEARNED SOCIETIES, &c.

Vargasia. Boletin de la Sociedad de Ciencias fisicas y Naturales de Caracas. *Caracas: Imprenta del Estado Bolivar.*

Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlinger. *Stockholm: Norstedt & Sons.*

Proceedings of the Lyceum of Natural History in the City of New York.

The Journal of the Historical and Archæological Association of Ireland.

Transactions of the Woolhope Naturalists' Field Club.

Fifth Report of the Quekett Microscopical Club.

Proceedings of the Royal Society.

" " Royal Institution of Great Britain.

Monthly Notices of the Royal Astronomical Society.

INDEX TO VOL. VII.

A.

B.

C.

H.

M.

N.

O.

T.

END OF VOL. VII.

LIST OF PLATES IN VOLUME VII.

LIST OF WOODCUTS IN VOLUME VII.

London: Printed by W. Clowes & Sons, Stamford Street and Charing Cross.